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FINAL REPORT
FOR
ABRES INSTRUMENTATION
AND
RANGE SAFETY SYSTEM
(AIRSS) PROGRAM

ANR 67-010

GENERAL DYNAMICS
Convair Division

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LA. AFS, CMR, 90045

FINAL REPORT
FOR
ABRES INSTRUMENTATION
AND
RANGE SAFETY SYSTEM
(AIRSS) PROGRAM
ANR 67-010

CONTRACT AF04(694)-875

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L. H. AF Station, Calif
90045

15 NOVEMBER 1967

PREPARED BY
CONVAIR DIVISION OF
GENERAL DYNAMICS
SAN DIEGO, CALIFORNIA

FORWARD

This report is written to summarize the Contractor's efforts in the design and development of the ABRES Instrumentation and Range Safety System (AIRSS). Technical problems, solutions and/or achievements are presented.

The report is submitted in accordance with Attachment 2, Contractor Data Requirements List (Sequence Item Number 3), to Exhibit "A" of Contract AF04(694)-875.

Approved by:


W. J. Giesenschlag
Program Manager - AIRSS
Launch Vehicle Programs

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SUMMARY

This report presents Convair's efforts to design, develop, fabricate, qualify, flight test and deliver the ABRES Instrumentation and Range Safety System (AIRSS).

The AIRSS design does not necessarily represent an advance of the state-of-the-art, but utilizes proven devices and techniques to achieve the requirements of the AF04(694)-875 contract within the time period allowed.

The AIRSS mission reliability goal requirement of .9950 for the telemetry set was surpassed with a predicted mission reliability of .9967.

The AIRSS telemetry set was successfully qualified in that testing conducted verified performance which either met or exceeded all technical requirements and/or constraints specified in the contract - with no deviations.

A total of thirty-five (35) AIRSS kits representing eight (8) configurations were delivered into GFP inventory. The contract was completed within the "period of performance" with completion of hardware deliveries occurring four (4) months ahead of the contract schedule and one (1) month ahead of the "incentive" schedule.

SECTION I

INTRODUCTION

The AIRSS End Item, 64-1004, designed, developed and provided by Convair, is the second generation of such a system. The first generation system, also designed and developed by Convair, was the Instrumentation and Range Safety System End Item (IRSS), 27-0803.

The IRSS End Item consisted of several electronic canisters for telemetering (Signal Conditioning Canister, Signal Conversion Canister and Signal Transmitter Canister) all of which utilized tube type electronic equipment resulting in low reliability under missile flight environments. In addition, the system was bulky (several canisters) taking up a large space envelope and very inflexible to changes.

By contrast, the AIRSS End Item contains only one (1) electronic canister for telemetering. The telemetry set employs all solid state circuitry design for higher reliability, modular construction for ease of maintenance, requires a very small space envelope and through an internal patching arrangement offers greater flexibility.

The AIRSS End Item was developed for Air Force use on Nike/ABRES experimental and space weapons research programs and is designed to interface with the Atlas Nike/ABRES E/F standard baseline booster. The versatility of the telemetry set, however, makes it adaptable for use in other military applications with a minimum of cost and effort.

The primary development effort under the AF04(694)-875 contract is in the area of the AIRSS telemetry set. Convair's development of the telemetry set is unique in that it is the first telemetry set employing all solid state modular construction, fabricated by the contractor and fully qualified to meet the Electro-Magnetic Interference requirements of MIL-I-26600 in addition to the total flight environments of the Atlas E/F booster. The design, qualification and fabrication of the telemetry set is the basic subject of this report, dealing primarily with the significant problem areas encountered and their solutions during the design, testing and manufacturing phases of the AIRSS Program.

SECTION 2

DESIGN

2.1 GENERAL REQUIREMENTS

The general technical requirements and limitations for design established for the AIRSS End Item are:

- a. System will consist of a telemetry set (commutation, signal conditioning, and RF transmission contained in a single housing), transducers, inter-connecting wiring harnesses, tubing, bracketry, etc. as necessary to provide a complete pre-flight and in-flight monitoring capability.
- b. Maximum reliability (.995 probability of mission success) through the use of solid state components and 50% derating of components (telemetry set only).
- c. Maximum flexibility for adaptation to mission peculiar requirements and future growth potential.
- d. Maximum size (1665 cubic inches) and maximum weight (29.6 pounds) for reduced space envelope (telemetry set only).
- e. Maximum maintainability with respect to field repair and/or adjustments (telemetry set only).
- f. Interface with Nike/ABRES E/F booster antennas, electrical power systems and destruct ordnance.
- g. Interface with existing aerospace ground equipment, test range telemetry equipment and IRIG Standards.
- h. Advance of the state-of-the-art is not desired. Optimum use of proven devices and techniques is desired in order to accomplish the development within a limited time period (approximately nine months).

Design of an Instrumentation and Range Safety System based upon current technology, therefore, is the design goal with emphasis placed upon reliability, flexibility and maintainability.

2.2 TELEMETRY SET DESIGN

The AIRSS telemetry set (64-40103) is a PAM/FM/FM system design conforming to IRIG Standards operating at frequencies of 240.2 and 245.8 megacycles, but capable of operating at any frequency between 215 and 260 megacycles. The unit consists of three major assemblies, commutator (64-01005), transmitter (64-01004) and signal conditioner (64-40149). See Figure 2.2. Of these,

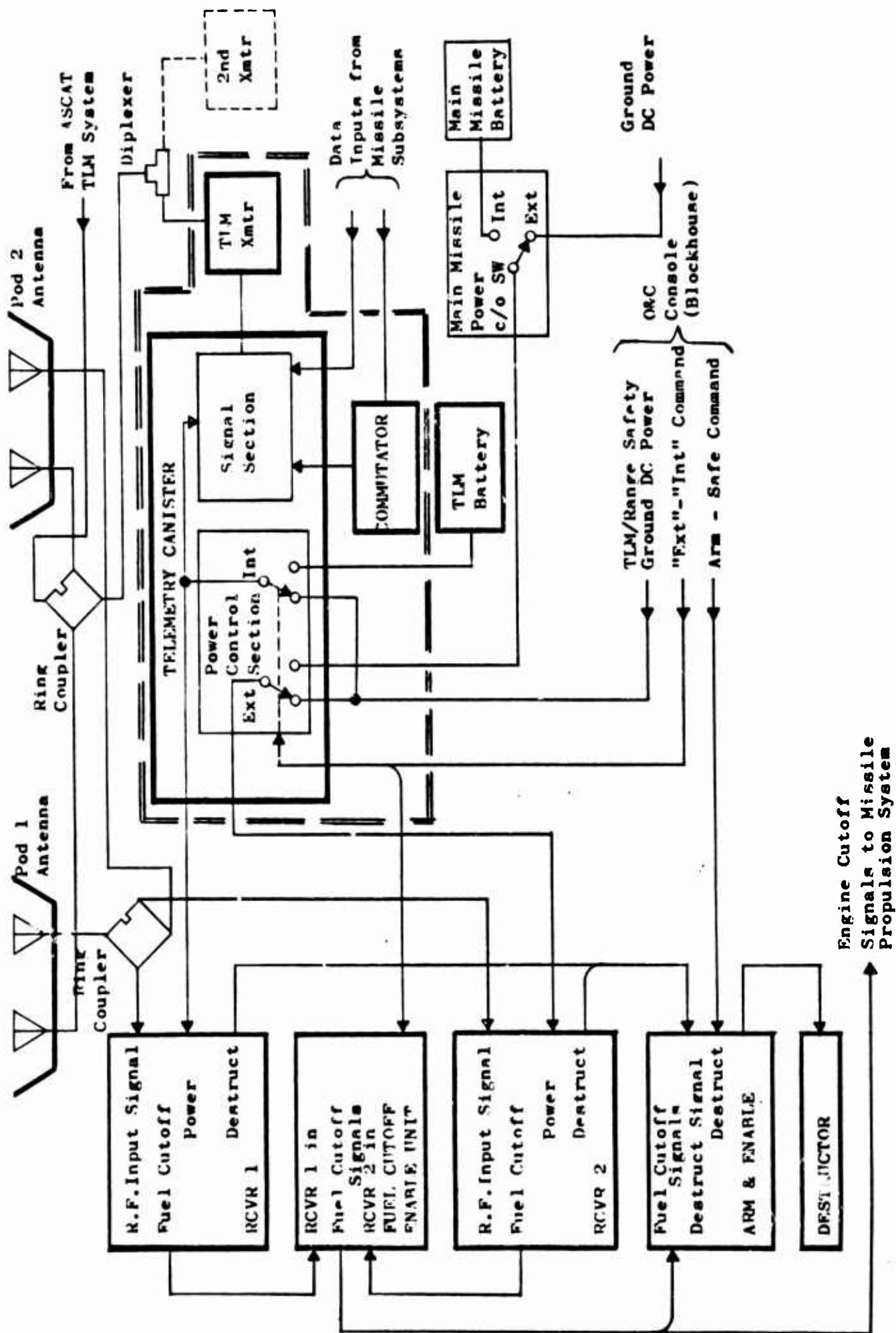


Figure 2-1

FUNCTIONAL BLOCK DIAGRAM, AIRSS SYSTEM

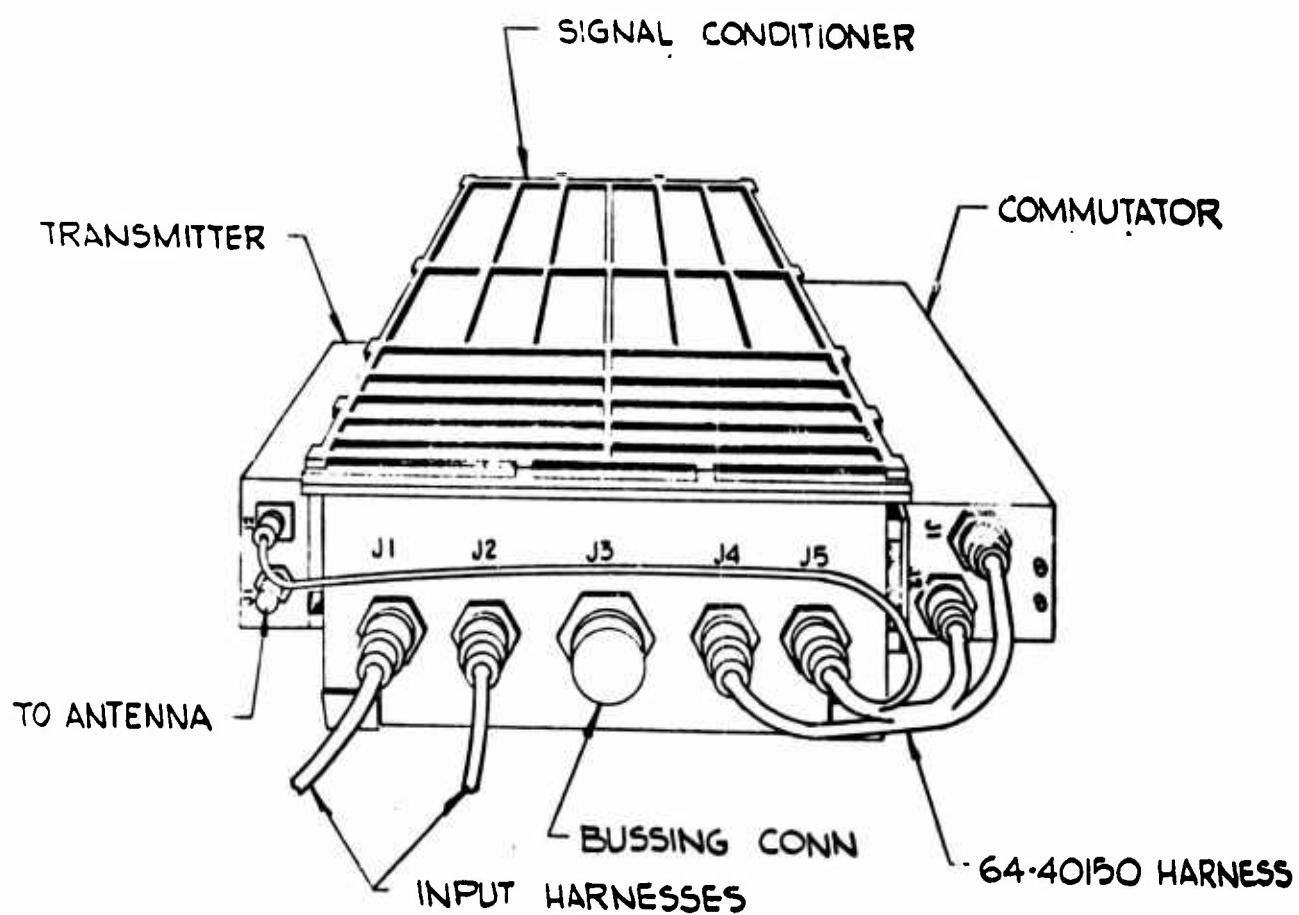


FIG. 2-2

the signal conditioning unit is the basic canister with the commutator and transmitter mounted externally to its sides permitting easy access to remove for repair and/or replacement.

Operationally, the set consists of twelve (12) active channels (4 commutated, 2 direct and 6 continuous) with provisions allowing for expansion to nineteen (19) channels (5 commutated and a maximum of 14 continuous).

The set is of modular construction (all three major assemblies) for ease of access, removal, replacement, maintenance and inspection in keeping with maximum flexibility and maintainability and utilizes solid state components and derating practices in all areas of design for maximum reliability.

2.2.1 Transmitter

The transmitter is procured from Dorsett Electronics, Incorporated, Tulsa, Oklahoma, in accordance with Convair Specification 64-01104, Specification Control Drawing 64-01004. The unit is a TR-260 representing a redesign of the Dorsett T-260 furnished for the Pershing Weapons System. The redesign is primarily in the areas of increased R.F. output power and frequency stability.

The transmitter unit is housed in an aluminum case with maximum dimensions not exceeding 5.3 x 3.3 x 2.0 inches, maximum volume (including connectors) not exceeding 35 cubic inches and weighs slightly less than the allowable 25 ounces. The unit operates at preset frequencies of 240.2 or 245.8 megacycles. The frequency is crystal controlled and can be altered to any standard setting between the ranges of 215 and 260 megacycles at the vendor's plant. The unit features a "power polarity protection" design such that reversal of input voltage polarity will not damage the unit or result in deterioration of performance after restoration of correct polarity.

Some of the more pertinent design characteristics are:

- a. R.F. Output Power: Has a minimum outpower of 5 watts into a 50 ohm resistive load.
- b. Frequency Stability: The carrier center is stable within ± 0.005 percent of the assigned frequency.
- c. Bandwidth: Bandwidth of the transmitted signal is restricted to ± 250 KC.
- d. Harmonic Distortion: Total harmonic distortion does not exceed 1 percent.
- e. Intermodulation Distortion: Distortion produced at a peak deviation of ± 125 KC is less than 0.5 percent (measured using the difference frequency method).
- f. Electromagnetic Interference: Complies in all aspects to requirements of MIL-I-26600 except that antenna conducted spurious and harmonic output outside the prescribed bandwidth is a minimum of 60db below the transmitter carrier level.

There are no external controls or adjustments. The unit is sealed to lock out moisture and other contaminants. Purging and pressurization is not required.

In operation, the transmitter accepts an amplified composite signal which in turn varies the R.F. carrier frequency at the modulated rate to develop a true FM output signal.

See Figure 2.3 for a functional block diagram.

2.2.2 Commutator

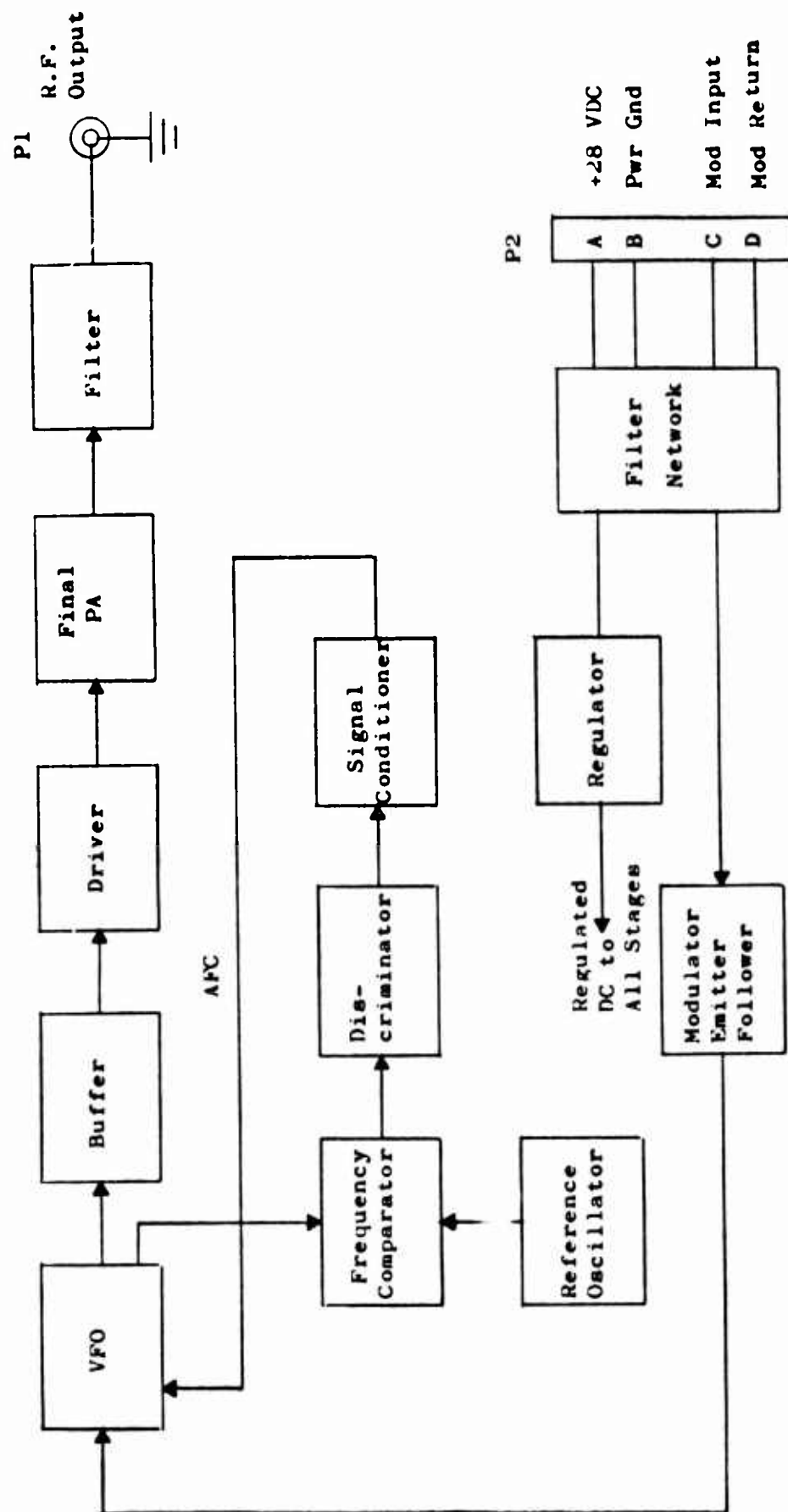
The commutator is procured from Stellarmetrics Incorporated, Santa Barbara, California, in accordance with Convair Specification 64-01005, Specification Control Drawing 64-01005. The unit is an all electronic functional design using solid state components and modular construction.

The commutator unit is housed in an aluminum case with maximum dimensions not exceeding 3.8 x 4.0 x 11.5 inches maximum volume not exceeding 175 cubic inches and weighs approximately 3.8 pounds (allowable is 6.0 pounds). The commutator has 4 sections or poles with provisions for a fifth pole which can be added. Each pole is divided into 30 information segments. Five segments of each pole are utilized as calibration level and frame synchronizing pulses, leaving 25 segments for data. Two commutation speeds are utilized. Poles 1 and 2 operate at 5 samples per second (SPS) and poles 3 and 4 operate at 10 SPS. Pole number 3 differs from the others in that the first 10 segments of the frame are designed to accept low level (0 to 43 millivolt) signals. A common differential amplifier is used to amplify the low level signals into 33 1/3% "off" time and 66 2/3% "on" time. During the "off" time, clamp circuits hold the output voltage at a -1.25 VDC reference level creating a synchronizing pulse for each data segment. These pulses can be used to synchronize ground decommutation equipment to individual data segments.

Basically, the commutator consists of a clock (oscillator) which drives a counter. The counter, in turn, drives a switching device, which comprises a bank of solid state data gates. There is one data gate for each input channel, with discrete counter stage being necessary to drive each gate. The solid state gates consist of transistor switches driven by a gated high frequency oscillator. When closed or "on", the gate presents less than 50 ohms in series with the data path. The open circuit of "off" resistance is well in excess of 100 megohms. The output from each pole of the commutator is a sequential pulse train with the pulses varying in amplitude between the limits of -1.25 and +5.0 VDC as a function of the individual data channel amplitudes. The output signal of each pole is applied to a subcarrier oscillator in the signal conditioning unit. See Figure 2.4 for a functional block diagram.

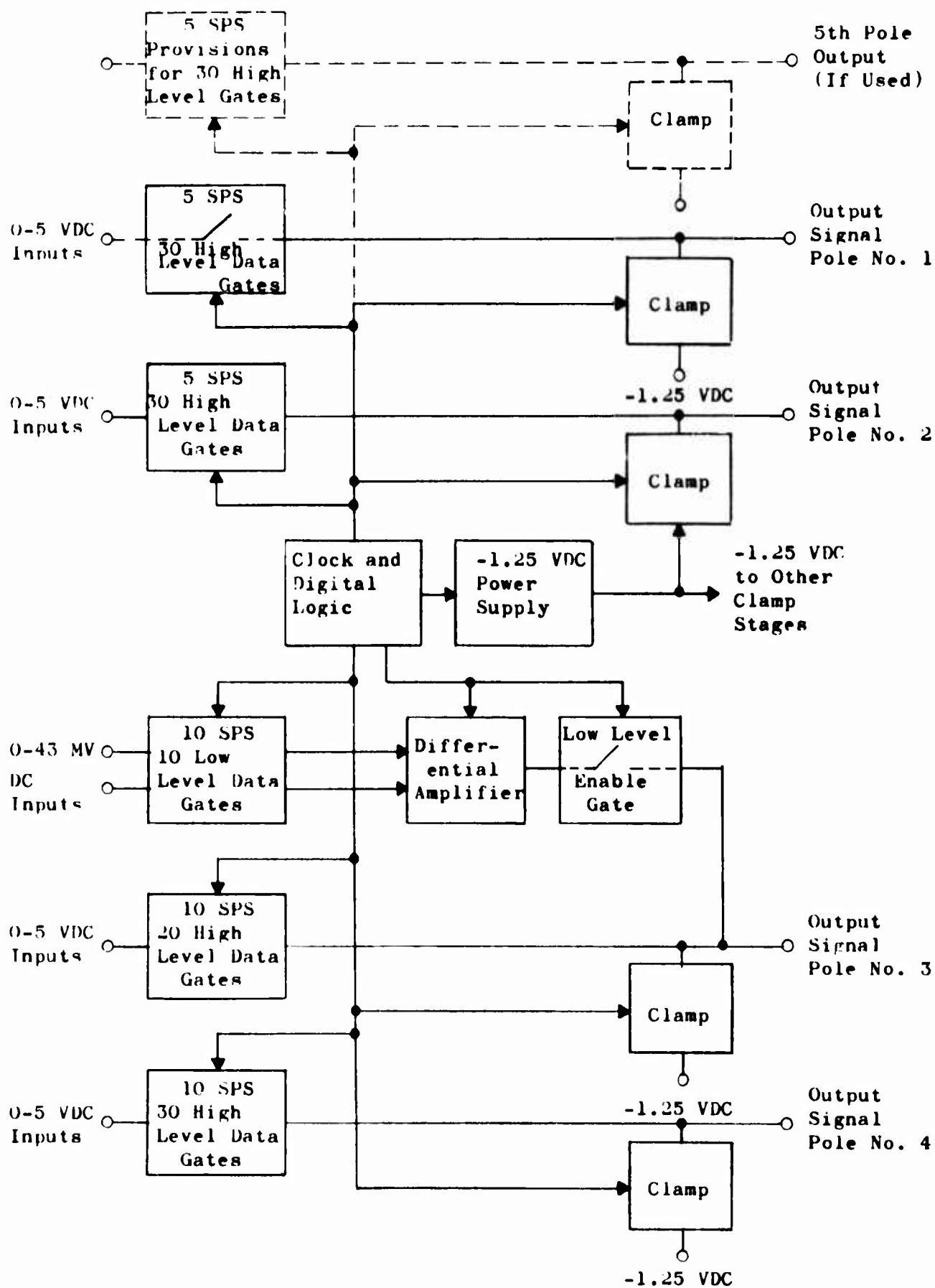
Some of the more pertinent design characteristics are:

- a. Input: High level (0-5 VDC); low level (0-43 millivolts DC).
- b. Input Impedance (low level): 200K ohms.



FUNCTIONAL BLOCK DIAGRAM, TRANSMITTER

Figure 2-3



FUNCTIONAL BLOCK DIAGRAM, ELECTRONIC COMMUTATOR

- c. Back Current: Less than 200 nanoamperes during "off" time. Less than 2 microamperes during "on" time.
- d. Linearity: High level ($\pm 0.2\%$ of straight line between end points). Low level ($\pm 1.0\%$ of straight line between end points).
- e. Sampling Rate Stability: $\pm 1.0\%$ of nominal.
- f. Channel Offset: Less than 25 millivolts peak-to-peak (equal inputs).
- g. Crosstalk: Less than 0.1% with any combination of input voltages and sound impedances of 10K ohms or less.
- h. Channel Noise: Less than 25 microvolts peak-to-peak exclusive of switching transients.
- i. Low Level Drift: Less than 50 millivolts (referred to 0-5 volt output).
- j. Electronic Magnetic Interference: The unit complies with all the requirements of MIL-I-26600 with the following exceptions:

Conducted interference measured between 15.4 and 17.0 megacycles is above the acceptable specification limits by:

+6.0 db @ 15.4 mc
 +9.0 db @ 15.9 mc
 +5.0 db @ 16.0 mc
 +1.0 db @ 17.0 mc

There are two external adjustments. These are low level amplifier gain adjustment and off-set adjustment. The unit is sealed to lock out moisture and other contaminants. Purging and pressurization are not required.

2.2.3 Signal Conditioning Unit

The signal conditioning unit or canister is housed in a mechanical aluminum case with removable covers. The unit is sealed to lock out moisture and other contaminants and designed to withstand pressure or vibration variations caused by temperature cycles, transportation, or use. Purging and pressurization are not required. External cooling is not required due to use of solid state components. Access to the signal conditioning equipment and other mounted hardware is gained by removing the top cover. Access to the wiring harness is gained by removing the bottom cover. Maximum dimensions of the unit are 19.0 x 7.0 x 11.0 inches with a maximum volume of 1465 cubic inches and weight of 22.0 pounds.

The signal conditioning canister contains the following major subassemblies:

- a. Subcarrier oscillators.
- b. Mixer amplifier.
- c. Electrical mounts

- d. Signal conditioning modules.
- e. Precision power supplies.
- f. Patchboard assembly.
- g. Power changeover relays.

The signal conditioning canister supplies +5.1 volts DC excitation through isolation resistors for potentiometer type transducers and receives a 0 - 5 volt DC signal from each one in return. Other inputs include low level (0 - 75 MV) signals from thermocouple type transducers, pre-conditioned measurements in the 0 - 5 VDC range, and special voltage and frequency measurements from missile subsystems.

Input signals not requiring signal conditioning are routed directly through the patchboard assembly where they are cross-patched to the input of the commutator. Signals requiring conditioning are routed to the signal conditioning modules. The output signals from the commutator and the outputs of the signal conditioning modules are then routed through the patchboard and cross-patched to the subcarrier oscillator inputs. Output frequencies of the SCOs and direct inserted frequency measurements are then summed on a composite signal line. The mixer amplifier accepts this signal and amplifies it to a level compatible with the desired transmitter deviation. This composite signal is then routed to the Transmitter where it frequency modulates a radio frequency carrier. The power changeover relays control the power source selection for the telemetry set and the range safety receivers. See Figure 2.5 for a functional block diagram.

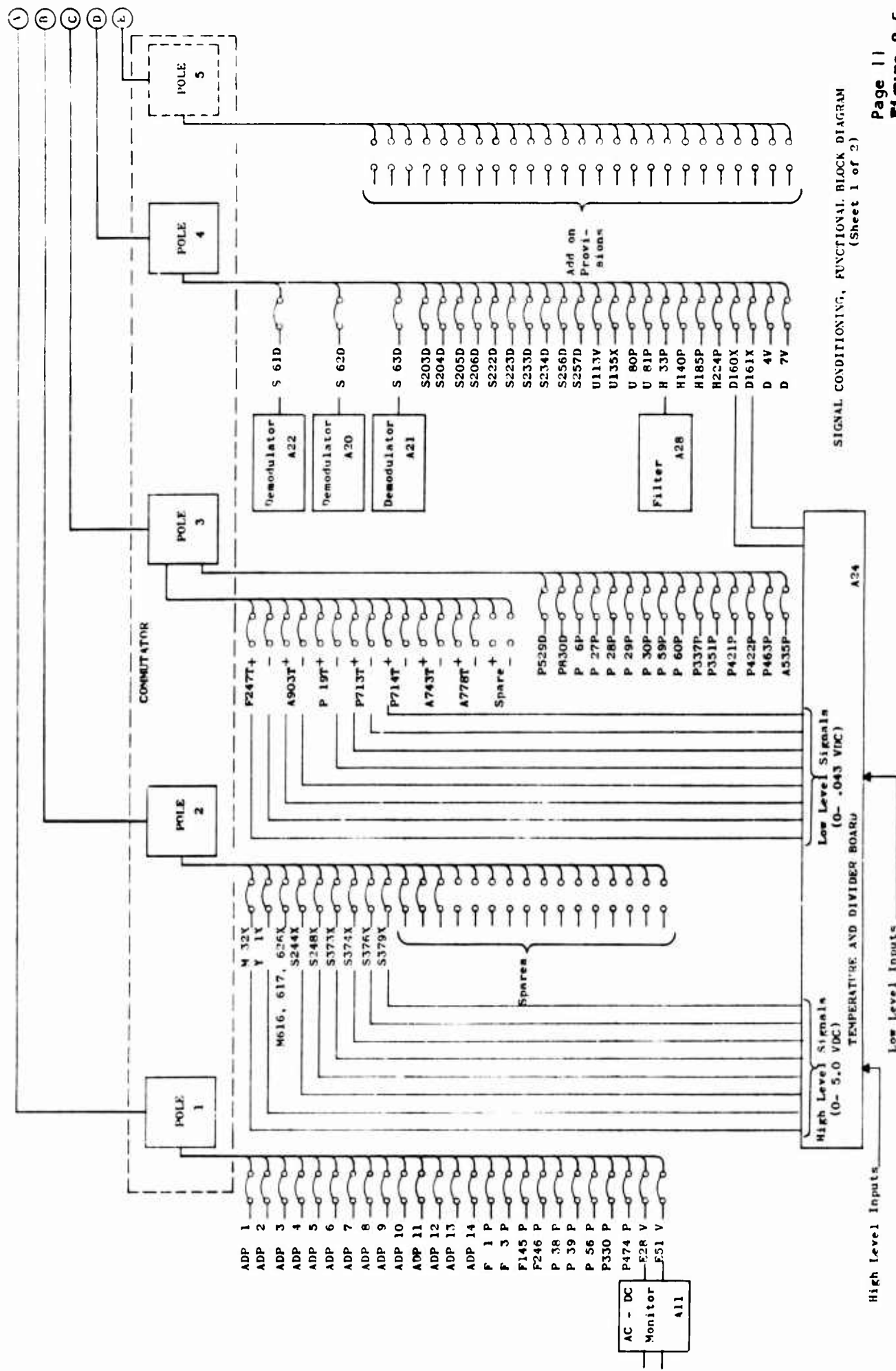
2.2.3.1 Subcarrier Oscillators

The subcarrier oscillators (SCOs) are procured from Dorsett Electronics, Incorporated, Tulsa, Oklahoma, in accordance with Convair Specification 64-01106, Convair Specification Control Drawing 64-01006. The signal conditioning unit contains space in the Electrical Mounts for 19 subcarrier oscillators, with 10 being active in this design. The balance of spaces have dummy loads installed thus allowing addition of future SCOs without having to revise the "pre-emphasis schedule."

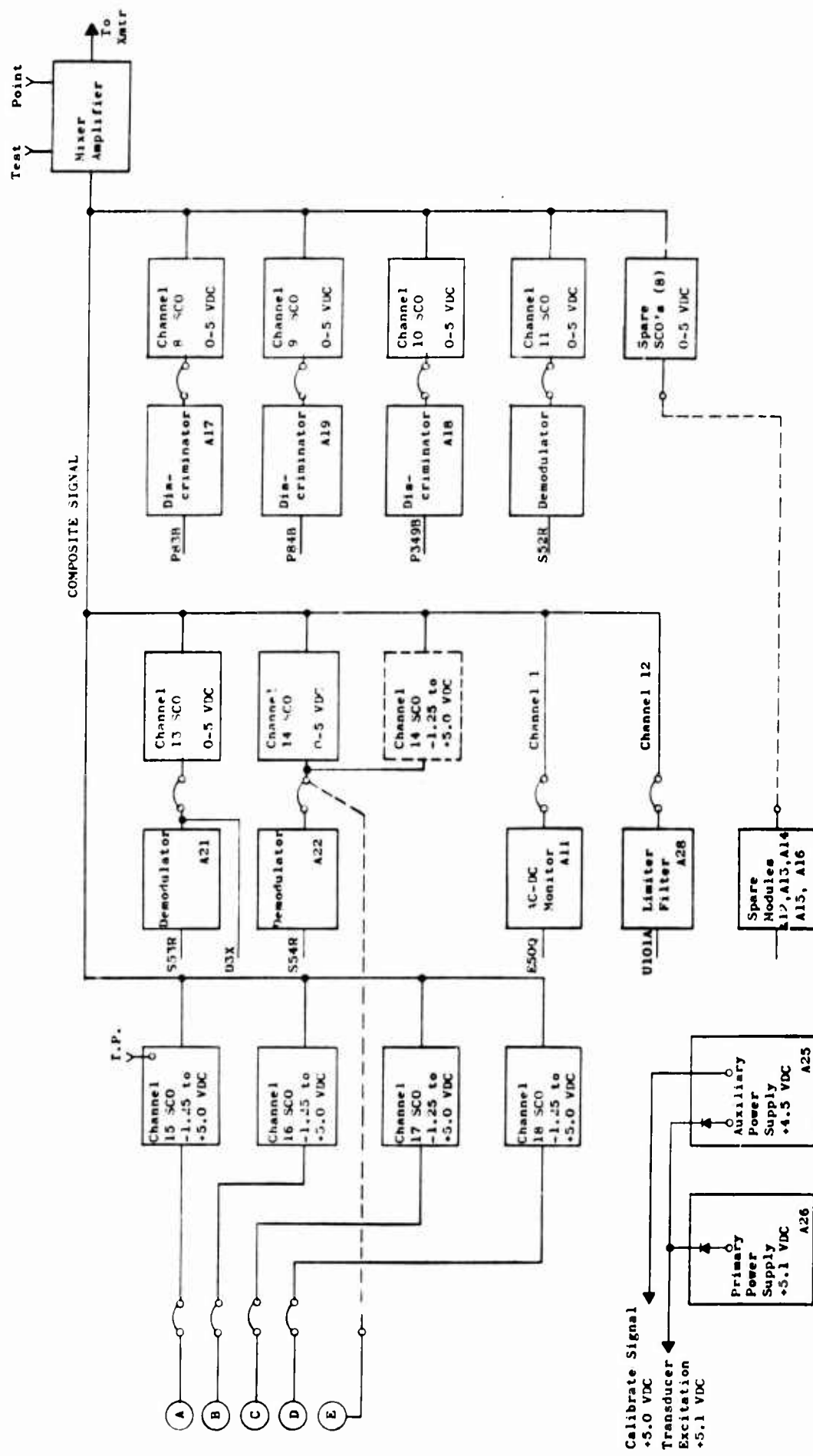
Each SCO consists of a voltage controlled oscillator stage followed by an output filter stage. Center frequencies and bandwidths correspond to standard IRIG telemetry channels. Two basic input signal voltage ranges are used: -1.25 to +5.0 VDC for commutated channels and 0.0 to +5.0 VDC for continuous measurement channels. A positive going input signal voltage causes an increase in output frequency. The SCO converts intelligence in the form of varying DC voltages into frequency modulated subcarrier signals. These signals are fed to the Mixer Amplifier via the Electrical Mounts.

2.2.3.2 Mixer Amplifier

The Mixer Amplifier is procured from Dorsett Electronics, Incorporated, Tulsa, Oklahoma, in accordance with Convair Specification 64-01107, Convair Specification Control Drawing 64-01007. The signal conditioning unit



SIGNAL CONDITIONING, FUNCTIONAL BLOCK DIAGRAM
(Sheet 1 of 2)



SIGNAL CONDITIONING, FUNCTIONAL BLOCK DIAGRAM
(Sheet 2 of 2)

contains one mixer amplifier. The mixer amplifier is mounted on the 64-01008-1 Electrical Mount. The mixer amplifier functions as a broadband linear amplifier and is used to supply the required voltage and impedance match to the modulator stage of the transmitter.

2.2.3.3 Electrical Mount

The electrical mounts are procured from Dorsett Electronics, Incorporated, Tulsa, Oklahoma, in accordance with Convair Specification 64-01108, Convair Specification Control Drawing 64-01008. There are two electrical Mounts (-1 and -2) contained in the signal conditioning unit. The mounts function as a holder for the SCOs and Mixer Amplifier. In addition, the mounts contain band edge limiting circuitry for the SCOs. The -1 mount contains provisions for 9 SCOs and 1 mixer amplifier and provides bandedge limiting for input signal voltage ranges of -1.25 to +5.0 VDC and 0.0 to +5.0 VDC. The -2 mount contains provisions for 10 SCOs with bandedge limiting circuitry for the 0.0 to +5.0 VDC range only.

2.2.3.4 Signal Conditioning Modules

Due to the different characteristics of the various input data signals, it is necessary to condition them into one basic output range (i.e. 0 - 5 VDC) to drive the subcarrier oscillators or stimulate commutator data segments over the designed range. This is accomplished by the signal conditioning modules. There are 13 modules located in the signal conditioning unit, 9 of which are utilized for measurement signal conditioning. The modules circuitry is designed for all solid state components mounted on printed circuit boards made from a copper clad glass cloth epoxy resin laminated material. The modules are a maximum 4.3 x 3.85 x .75 inches in dimension. After assembly of the components on the printed circuit board, the module is conformal coated to provide moisture protection and reduce vibration effects on the components. The modules plug into mounted receptacles in the signal conditioning housing and are held in place by screws through the module mounting bracket to the signal conditioner housing. There are 5 spare module slots in the housing providing a capability of 18 modules.

In addition to the nine (9) signal conditioning modules, there is also a current limiter, in-flight calibrator and two power supply modules.

The current limiter module provides protection to the 28 VDC source from shorts which might occur in the wiring or transducers for those measurements requiring +28 VDC excitation. The unit is self-resetting and can operate into a short with no degradation of performance when the short is removed.

The in-flight calibrator module is a "provision only." A printed circuit board and 18 pair of wires plus a command wire are provided to permit calibrating 18 continuous channels by the addition of an in-flight calibrator module. The module itself is not provided as a part of the AIRSS End Item.

The primary power supply module provides a precision +5.1 VDC excitation to the potentiometer type transducers. This module is sometimes referred to as the Transducer Power Supply.

The auxiliary power supply module has two functions. The first is to act as a backup supply to the primary power supply in case of failure. In this instance, it would provide an excitation voltage for transducers of +4.595 VDC (10% lower than the primary unit). Its second function is to supply a precision +5.000 VDC for calibration of commutated signals and excitation to the temperature bridge for resistive type temperature transducers.

2.2.3.5 Patchboard Assembly

The patchboard assembly is located in the signal conditioning unit. The purpose of the assembly is to permit the rechannelization of any one, several, or all signals by revision of the patching arrangement. All data measurements are routed through the patchboard assembly. The assembly is constructed in two parts. The rear section is rigidly mounted into the signal conditioning housing. The internal canister wiring interfaces with this section such that all input and output signals arrive at this point. The other section is comprised of an input and output panel which in turn are bridged together by patch wires.

All patching changes take place on this section which is removable and can be replaced in its entirety with a newly patched configuration.

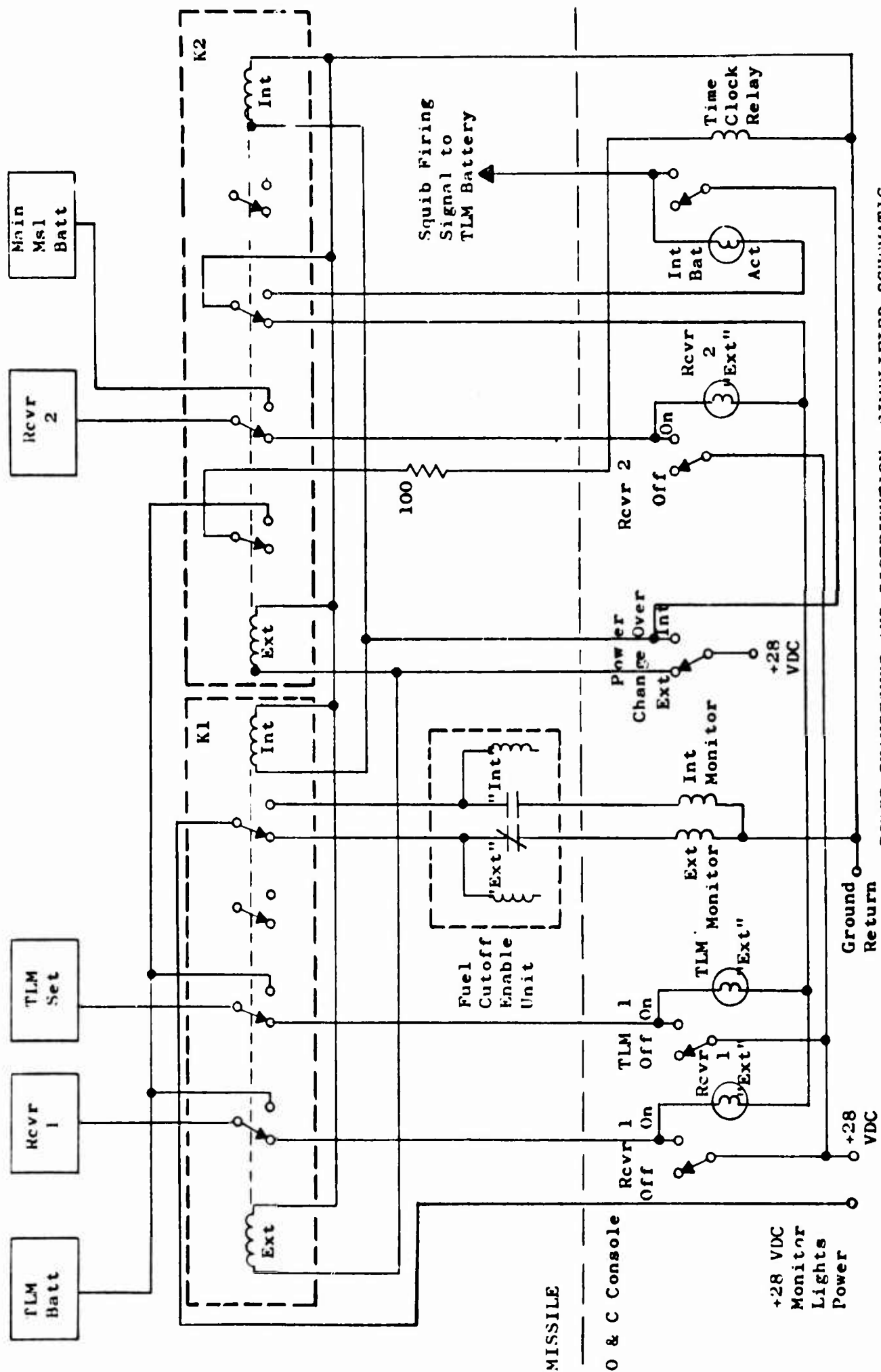
2.2.3.6 Power Changeover Relays

There are two power changeover relay assemblies located in the signal conditioning housing. Their function is to switch between external and internal power sources. The switches are magnetic latching type relays, each with four single pole double-throw contacts. Each switch has one set of contacts which switches power to one of the two range safety command receivers. One switch has a set of contacts which switches power to the AIRSS telemetry set. One switch has one set of contacts which are wired so as to switch the Atlas fuel cutoff enable unit between enable and disable. See Figure 2.6 for schematic.

2.3 GENERAL DESIGN EFFORT

Design efforts for the AIRSS End Item were initiated with definitization of the AF04(694)-875 contract on 3 January 1967. A Preliminary Design Review (PDR) was accomplished on 21 January 1966. Data presented and reviewed were:

- a. Contract End Item Specification 64-00029.
- b. Configuration Management Plan, ANR66-001.
- c. Long Lead Evaluation Report, ANR 66-002.
- d. Personnel Subsystem Plan, ANR66-003.
- e. Engineering Release Analysis, ANR66-004.
- f. System Safety Plan, ANR66-005.
- g. Reliability Plan, ANR66-006.



POWER CHANGEOVER AND DISTRIBUTION, SIMPLIFIED SCHEMATIC

Figure 2-6

- h. Preliminary Design Evaluation Drawings, ANR67-006.
- i. Preliminary Design Report, ANR66-007.
- j. Program Plan and Schedules, ANR66-008.
- k. Environmental Analysis Report, BK66-002.
- l. Preliminary Drawings for Factory Support Equipment (FSE).
- m. Maintenance and Operations Manual Outline.

Significant milestones accomplished and agreements reached at PDR were:

- a. Technical approval was given on Convair's design approach to the telemetry set and incorporation of GFP IRSS (EID 27-0803) hardware in the first 15 flight article end item design.
- b. Agreement was reached on accomplishing the FACI in two phases:
 - Phase I Mock-up and FACI of telemetry set, B-1 Pod harness and major modified IRSS hardware. This configuration is basically the "Hybrid AIRSS."
 - Phase II Mock-up and FACI of new transducers, harness and tubing installations replacing designs using the IRSS hardware (telemetry set configuration is same as FACI'd in Phase I). This configuration is identified as the "Full AIRSS."
- c. Long Lead material procurement authorization was granted.
- d. Two production transmitter frequencies were established (240.2 and 245.8 megacycles).
- e. Factory Support Equipment design drawings would not be subject to AIRSS format or critical design review.
- f. Agreement was reached that Convair "make" item drawings would be pre-released (controlled released) and fabrication of hardware initiated prior to formal CDR. Each drawing would be reviewed by BSD/Aerospace prior to fabrication.

A critical design review (CDR No. 1) of the "Hybrid AIRSS" configuration was accomplished on 31 March 1966. Data presented and reviewed were:

- a. All formal AIRSS drawings (64-xxxxx) effective on the "Hybrid AIRSS" design.
- b. Interface Control Drawings.

A detailed review of all major subassemblies and assemblies of the telemetry set was conducted. Design data and a brief description of each subassembly and assembly was presented. There were no significant problems encountered

in the designs. Convair was given tentative technical approval on all designs.

A mockup of the "Hybrid AIRSS" configuration was accomplished on Atlas booster 119F and presented for FACI-Phase I review on 16 June 1966. FACI-Phase I was completed on 18 July 1966. Concurrent with the FACI effort was the initiation of qualification testing on the telemetry set (see Section 4 for testing).

A PDR for the AIRSS "Piggy-back" Flight Test Configuration was accomplished on 5 August 1966. It was determined that the first of two piggy-back flights would be made on Atlas booster 148F. A list of 20 measurements to be paralleled off the primary instrumentation system was agreed upon. Convair was directed to finalize the installation design based upon PDR agreements. Design was completed on 26 August 1966, however, the CDR was deleted by the customer (see Section 4, Testing).

A critical design review (CDR No. 3) of the "Full AIRSS" configuration was accomplished on 14 November 1966. A detailed review of AIRSS drawings and designs for new transducer, harness and tubing installations which replaced the obsolete IRSS designs was conducted. There were no significant problems encountered in the designs, however, one significant determination was made in relation to the drawing format. Since there was a contract requirement to supply the customer with a Data Reprocedure Package of the "Full AIRSS" configuration, it was decided that all AIRSS drawings (64-xxxxx) would be in the same format. The format established and agreed upon was:

- a. All hardware and installation drawings will be no larger than "E" size (there were three exceptions due to the nature of the drawings).
- b. The Parts List will be separate from the drawing.
- c. There will be no Find Numbers used in the Parts List or on the face of the drawings. Part numbers will be used on face of drawings.
- d. When Convair internal control numbers (10 digit, etc.) are used, the vendor's part number and/or Code Identification number will be included.
- e. There will be no bracket details on face of installation drawings. These will be contained in a Bracket and Detail Parts Manual.
- f. There will be no machined parts details on face of installation drawings. These will be contained in a Machined Parts Manual.
- g. There will be no transducer assembly details on face of installation drawings. These will be contained in a Transducer Assembly Manual.
- h. There will be no tubing details on face of installation drawings. These will be contained in a Tube Bend Data Manual.
- i. All drawings and detail parts will be identified with the 64-xxxxx series numbers with the exception of existing Spec Control Drawings for O.S.P. hardware such as transducers.

A mockup of the "Full AIRSS" configuration was accomplished on Atlas booster 75F and presented for FACI-Phase II on 18 November 1966. FACI Phase II was completed on 8 February 1967 establishing the AIRSS baseline configuration for purposes of reprourement. With the approval of FACI-Phase II, all design efforts under the -875 contract were completed.

2.4 MAINTAINABILITY

The transmitter and commutator, two of the three major components making up the AIRSS telemetry set, are externally attached to the signal conditioning housing by mounting bolts and have quick-disconnect plug-and-jack connectors (transmitter also has one threaded coaxial connector). Removal of the complete telemetry set from the missile when a fault is isolated to these units is not necessary. Removal and/or replacement in a minimum of time is facilitated by these features. In addition, there are no adjustments or calibrations required when either unit is changed. The removal or replacement of these units requires no special tools.

The signal conditioner canister is secured in place by six (6) bolts. The canister plug-and-jack electrical connectors are all located at the same end of the canister. Removal of the entire telemetry set in a minimum of time is facilitated by these features. Standard tools can be used.

All major assemblies of the signal conditioner unit are the plug-in variety and can be readily removed and replaced using standard tools. Since all plug-in units of the signal conditioner are pre-adjusted and set, no alignment or adjustments at the canister level are required.

2.5 FLEXIBILITY

Modular design and signal patching are two outstanding features of the AIRSS telemetry set which allows for maximum flexibility. These provide flexibility in the areas of:

- a. Continuous Data - The set has the capacity for 18 subcarrier channels. Currently ten channels are in use: six for continuous data and four for commutated data. The balance of the subcarrier spaces contain dummy loads. To increase the quantity of continuous measurements simply remove the dummy loads, insert a new subcarrier oscillator and reprogram the patchboard. No adjustment to the set is required.
- b. Data Format - Currently, the set is PAM/FM/FM. To convert to PCM/FM/FM, simply delete the subcarrier oscillators and commutator and replace with a programmer/digitizer and single oscillator.
- c. Transmitter Frequency - At the present time, the set has a frequency range of 225 to 260 megacycles. It is readily converted to S-Band by replacing present transmitter with an S-Band transmitter.
- d. Signal Patching - Signal patching is accomplished by patchboard connectors. All data signal paths, both conditioned and direct, pass through the patchboard. This gives the telemetry set built-in flexibility.

The patchboard design provides easy removal and replacement of one pre-programmed patchboard for another.

The signal conditioning canister can be opened at any time for measurement changes. Any module in the canister itself can be replaced without using special tools. Changes, then, ranging from an entire unit as transmitter down to altering data format, are simple and efficient.

2.6 GROWTH POTENTIAL

Again, the modular design feature of the AIRSS telemetry set provides maximum growth potential within these areas:

- a. Present Design - Within the limitations of the present telemetry set design, growth in the following areas are a reality:
 1. Continuous Data - With no adjustment to the set and replacing the subcarrier oscillator dummy loads with oscillators, the number of channels can be increased from 10 to 18.
 2. Commutated Data - The commutator and canister are prewired for five poles. The fifth pole can be provided by installing a commutator with the fifth pole circuitry included.
 3. Measurement Quantity - As now constituted, the set can handle 110 measurements. To increase the number of measurements by:
 - 10%, add cross-connects to the patchboard and plug in signal conditioning modules into spare spaces as required;
 - 40%, add cross-connects to the patchboard and activate the fifth commutator pole.
 4. Signal Conditioning - There are five, prewired, spare spaces which can accommodate the requirements for additional signal conditioning.
- b. New Design - By changes to the present design, growth in the following areas can be realized:
 1. Measurement Quantity - The number of measurements the set can handle with its present commutator (110) can be increased up to 255 by changing the commutation format of the telemetry set to a none-return-to-zero (NRZ). This is done by replacing the present commutator with a 3 pole NRZ commutator and providing 3 subcarrier oscillators and a mount compatible with the NRZ format.
 2. Frequency - Frequency range can be changed to S-Band by replacing the present bolt-on VHF transmitter with an S-Band transmitter which bolts on to the same mechanical interface.
 3. Data Format - Conversion to PCM/FM/FM from PAM/FM/FM can be accomplished by deleting the subcarrier oscillators and commutator and replacing them with a programmer/digitizer and single oscillator.

SECTION 3

TESTING

3.1 REQUIREMENTS

Contract requirements stipulate a four (4) phase testing program to be implemented in the design development and delivery of the AIRSS End Item. These are:

- Phase 1 - Development Testing
- Phase 2 - Qualification Testing
- Phase 3 - Acceptance Testing
- Phase 4 - Flight Testing

The following is a summary of each testing phase and any significant problems and their solutions.

3.2 DEVELOPMENT TESTING

Development testing of the AIRSS telemetry set was accomplished in three parts:

- Proof testing circuit designs of subassemblies.
- Qualification testing of vendor procured parts.
- Overstress testing of Convair manufactured assemblies.

No all Convair subassemblies were subjected to testing, but only those items not previously proven in design.

3.2.1 Circuit Design Evaluation

Prior to fabrication the the printed circuit board assemblies, each circuit design and associated component parts were tested for these performances or to these conditions when applicable:

- a. Operational checks at ambient temperatures for transfer functions, linearity of transfer and stability at both the high and low range of their manufacturing tolerances.
- b. Operational checks over a temperature range of -50°F to +175°F.
- c. Long term stability of the circuit.
- d. Supply voltage variations up to ± 8 volts from nominal plus audio ripple superimposed on the supply voltage.
- e. Repetitive power on-off cycling.

- f. Operation into a short and reset capability.
- g. Frequency response and roll off rate.
- h. Total harmonic distortion.
- i. Operation from no-load to full-load conditions.

Testing was performed using breadboard models of the plug-in modules and sub-assemblies of the telemetry set. The purpose was to verify that circuit design and component parts of each module or subassembly performed satisfactorily under specified environmental and voltage extremes. In addition, the ability to reject audio and RF interference was also demonstrated where applicable. The canister housing was subjected to a vibration transmissibility test. This was accomplished using dummy subassemblies installed in the housing with simulated masses for the commutator and transmitter attached to the canister.

Final design of all modules and subassemblies were based on results of above testing. Results of the vibration transmissibility test proved the housing design to be satisfactory under the vibration environments imposed.

3.2.2 Vendor Qualification Tests

To insure that outside procured (OSP) components meet the AIRSS design requirements, testing requirements were imposed on each vendor through the procurement specs to qualify the item before Convair acceptance for use. The following is a summary of the characteristics proved for each item by vendor qualification testing:

Commutator (64-01005)

- a. Input current at rated voltage.
- b. Duty cycle.
- c. Sampling speed of each pole.
- d. Channel noise on all channels.
- e. Offset between channels.
- f. Crosstalk on low level and adjoining high level channels.
- g. Linearity on all channels.
- h. Gain characteristics on any one low level channel.
- i. Differential amplifier input impedance as measured at any low level channel input.
- j. Output signals and format of all channels.

- k. Output impedance of all channels.
- l. Overvoltage immunity, low level channel recovery on any one low level channel.
- m. Output pulse slope on any one low level channel.
- n. Back current on all high and low level channels.

Transmitter (64-01004)

- a. Input power.
- b. Frequency stability.
- c. Output power.
- d. Deviation linearity.
- f. Harmonic distortion.
- g. Intermodulation distortion.
- h. Bandwidth.
- i. Input impedance.
- j. Incidental FM.
- k. Input signal overvoltage.
- l. Overvoltage protection.
- m. Warmup time.
- n. Output impedance.

Subcarrier Oscillator (64-01006)

- a. Source impedance.
- b. Input overvoltage capability.
- c. Frequency response.
- d. Short term stability.
- e. Data feed-through.
- f. Input power.
- g. Audio susceptibility.
- h. Output impedance.

Mixer Amplifier (64-01007)

- a. Input impedance.
- b. Input overvoltage capability.
- c. Output impedance.
- d. Intermodulation distortion.
- e. Input power.
- f. Audio susceptibility.

Electrical Mount (64-01008)

- a. Input power.
- b. Linearity of the oscillators.
- c. Bandedge limiting with input signals of ± 35 VDC.
- d. Output impedance of each oscillator with input signal of ± 35 VDC.
- e. Frequency and amplitude output for input supply voltage variations.
- f. Output distortion and amplitude.
- g. Amplitude modulation of oscillator output.
- h. Input current at +28 VDC.

Qualification of all above vendor components to the requirements listed was successfully completed prior to delivery of production parts.

3.2.3 Overstress Testing

Overstress testing was performed on certain modules and subassemblies used in the telemetry set. The objective was to determine the failure level or design safety margin. Parts tested were selected at random from production stock following completion and acceptance of parts. The type of testing conducted was divided into two categories. These were:

- Category 1 Vibration environment. Tests were conducted at vibration levels equivalent to qualification levels and increased until failure occurred or acceptable design safety margins were demonstrated.
- Category 2 Temperature environment and electrical overstress. Temperature tests were conducted at levels equivalent to qualification levels and increased until failure occurred or acceptable design safety margins were demonstrated. In addition, repetitive on-off cycling at normal operating conditions for 1500 cycles were accomplished.

Parts subjected to Category 1 testing were:

Patchboard Assembly	64-40152 (Convair)
Magnetic Latching Relays (Power Changeover Switch)	BR/8AX-D5-V3-S7 (Babcock, Inc.)

Parts subjected to Category 2 testing were:

Primary Power Supply Module	64-40135
Auxiliary Power Supply Module	64-40161
AC-DC Monitor Module	64-40136
Limiter Filter Module	64-40137
Current Limiter Module	64-40139
Discriminator Module	64-40140
Demodulator Module	64-40134

All testing performed under both Category 1 and 2 conditions was conducted in a manner such that safe design margins were demonstrated as opposed to testing until a failure mode occurred. No significant failures or problems were encountered. Results were:

- a. Assemblies and parts tested under Category 1 conditions exhibited a design safety margin in excess of two.
- b. Assemblies tested under Category 2 temperature conditions exhibited a design safety margin between limits of -75°F and +195°F (design requirements are -40°F and +160°F).
- c. Assemblies tested under Category 2 electrical overstress conditions exhibited a design safety margin of at least two with power supply excursions over 100 milliseconds between 20 and 44 volts (design requirements and power supply excursions over 100 milliseconds between 20 and 36 volts).

3.3 QUALIFICATION TESTING

Qualification tests were performed on the AIRSS telemetry set for the purpose of evaluating the sets performance capabilities under the environmental conditions and test requirements specified in Attachment No. 3 to Exhibit "A" to the AF04(694)-875 contract entitled Technical Requirements Document for AIRSS dated 12 March 1965.

Testing was performed on a set which was identical in configuration to that reviewed in the First Article Configuration Inspection (FACI) - Phase I. Types of testing performed were:

TYPE TESTING	DESCRIPTION												
Temperature/Altitude/Humidity	Operation from -20°F to +160°F at 50,000 feet altitude and 5% humidity.												
Radiant Heat/Altitude	Operation under 500°F thermal radiation at 140,000 feet altitude.												
Humidity	Operation after a five (5) day exposure to 95% humidity over a cyclic temperature range of 65°F to 160°F for 6 hour periods.												
Explosive Atmosphere	Operation without ignition in an ambient explosive atmosphere.												
Acceleration	Operation under 20 Gs in three axis, 5 minutes each axis.												
Acoustical Atmosphere	Operation at an overall noise level of 151db.												
Cor Corona Arcing	Operation with no evidence of Corona at pressures of 0.01 microns to 760 MM of Mercury.												
Shock	Operation without malfunction during 90G Sawtooth shock pulse, 18 total shocks, 3 each in both plus and minus X, Y and Z axis.												
Vibration	Operation during exposure to 3 axis random sine vibration shaped as follows												
	<table><tr><th>Freq. Range</th><th>Sine, Comp.</th><th>Random Comp.</th></tr><tr><td>5 - 500 cps</td><td>3.5g (RMS)</td><td>0.10g²/cps</td></tr><tr><td>500-1000 cps</td><td>5.0g (RMS)</td><td>0.15g²/cps</td></tr><tr><td>1000-2000 cps</td><td>5.0g (RMS)</td><td>Roll-off at 9db per octave above 1000 cps.</td></tr></table>	Freq. Range	Sine, Comp.	Random Comp.	5 - 500 cps	3.5g (RMS)	0.10g ² /cps	500-1000 cps	5.0g (RMS)	0.15g ² /cps	1000-2000 cps	5.0g (RMS)	Roll-off at 9db per octave above 1000 cps.
Freq. Range	Sine, Comp.	Random Comp.											
5 - 500 cps	3.5g (RMS)	0.10g ² /cps											
500-1000 cps	5.0g (RMS)	0.15g ² /cps											
1000-2000 cps	5.0g (RMS)	Roll-off at 9db per octave above 1000 cps.											
EMI	Conformance to Electromagnetic Interference requirements of MIL-I-26600 during operation.												

Figures 3.1 thru 3.11 represent in graphical form some of the technical requires of qualification testing. Figures 3.12 thru 3.19 show the AIRSS telepak during a portion of qualification test setups.

Figure 3./

Altitude Profile

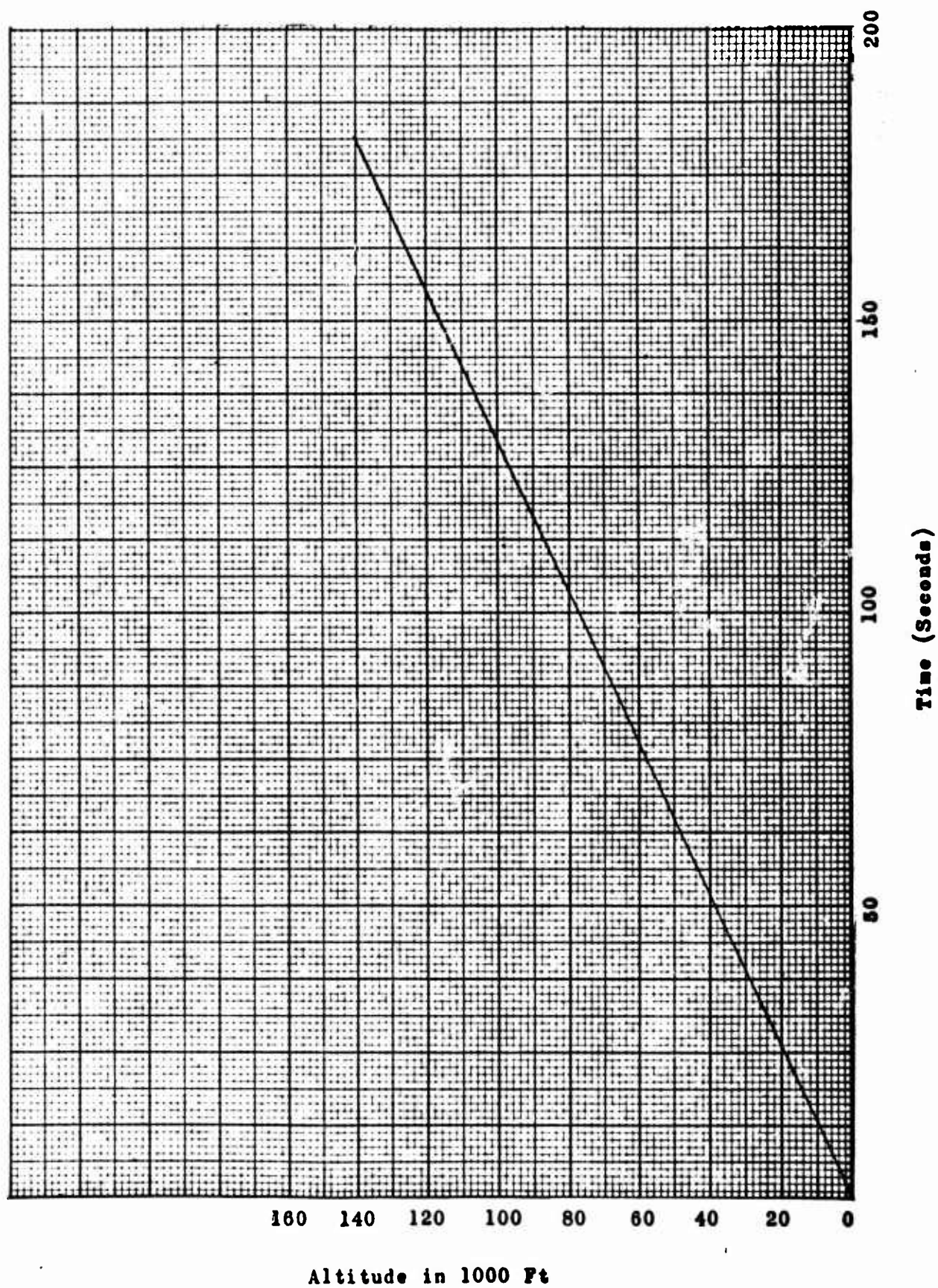


Figure 32

Thermal Source Surface Temperature

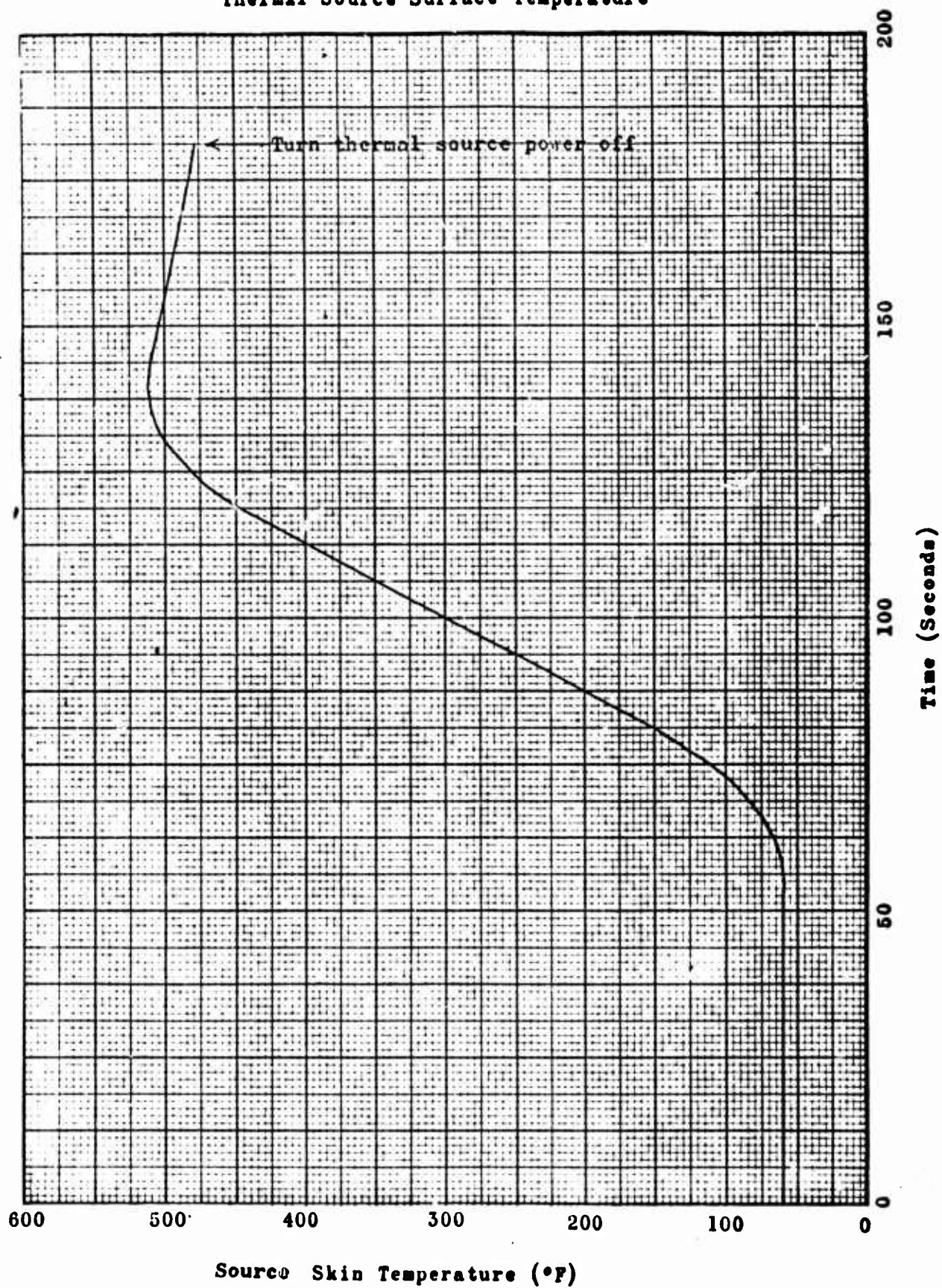


Figure 33

Sinusoidal Portion of Vibration

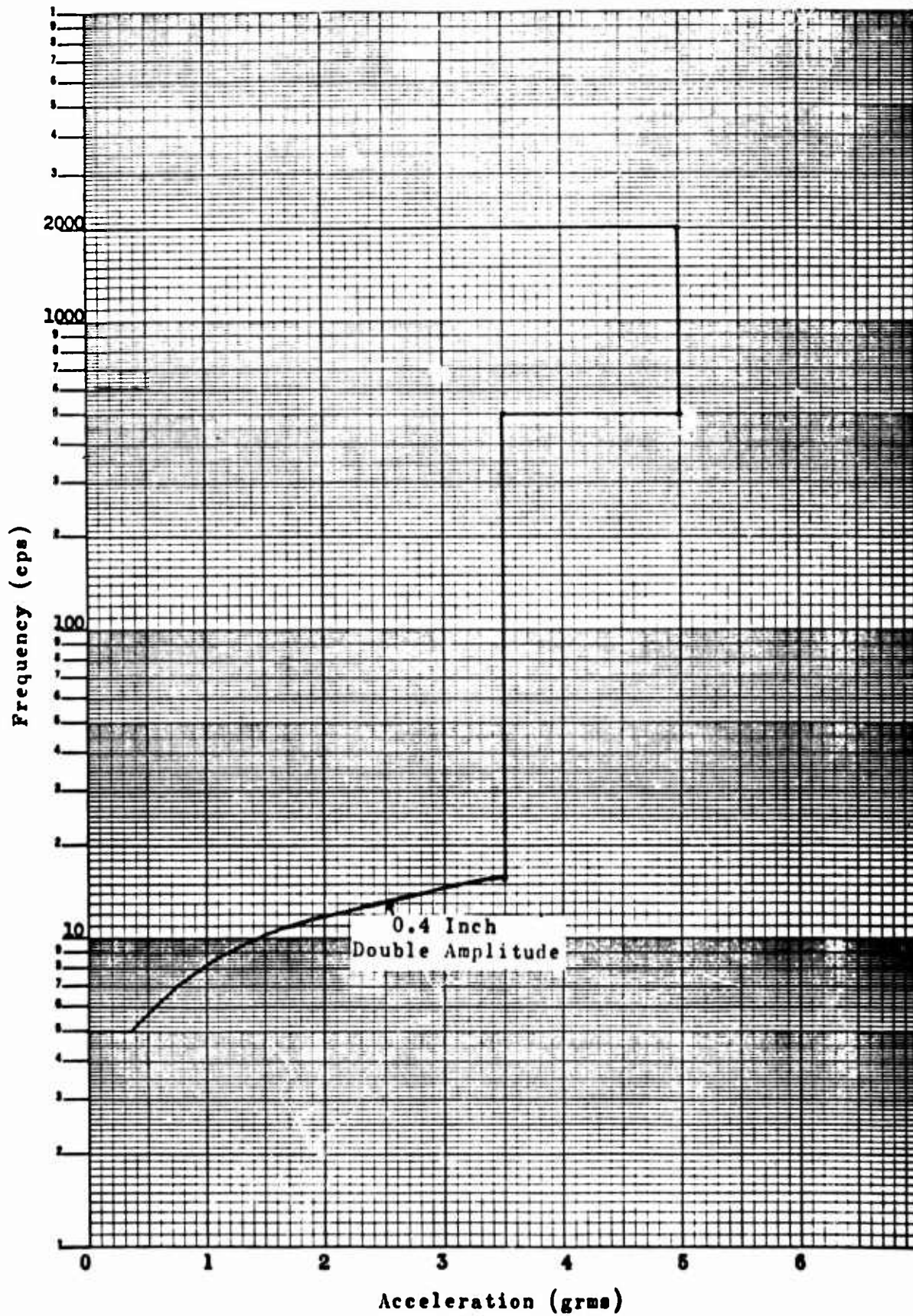
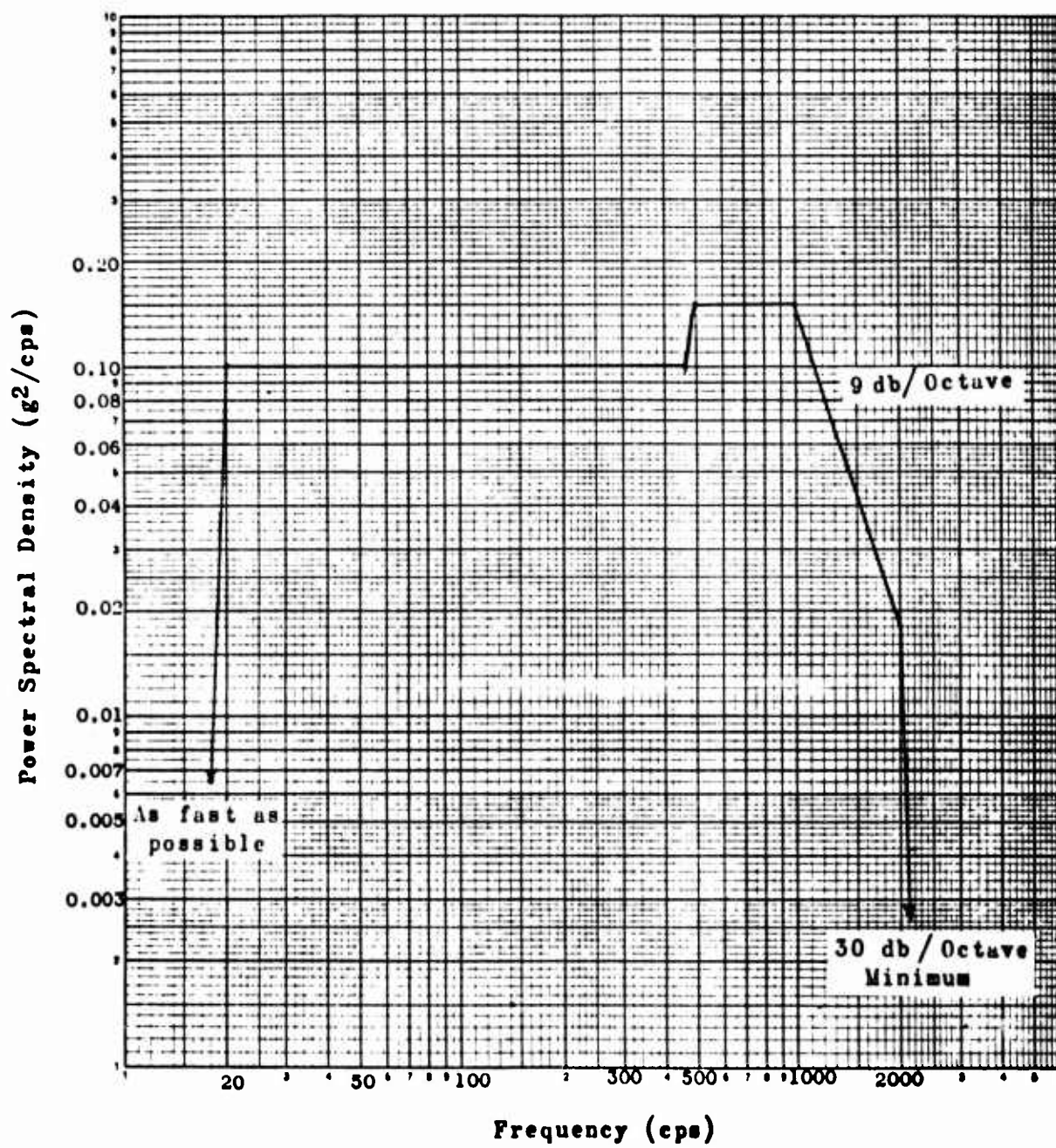


Figure 3.4

Random Portion of Vibration



SINUSOIDAL FREQUENCY (CPS)

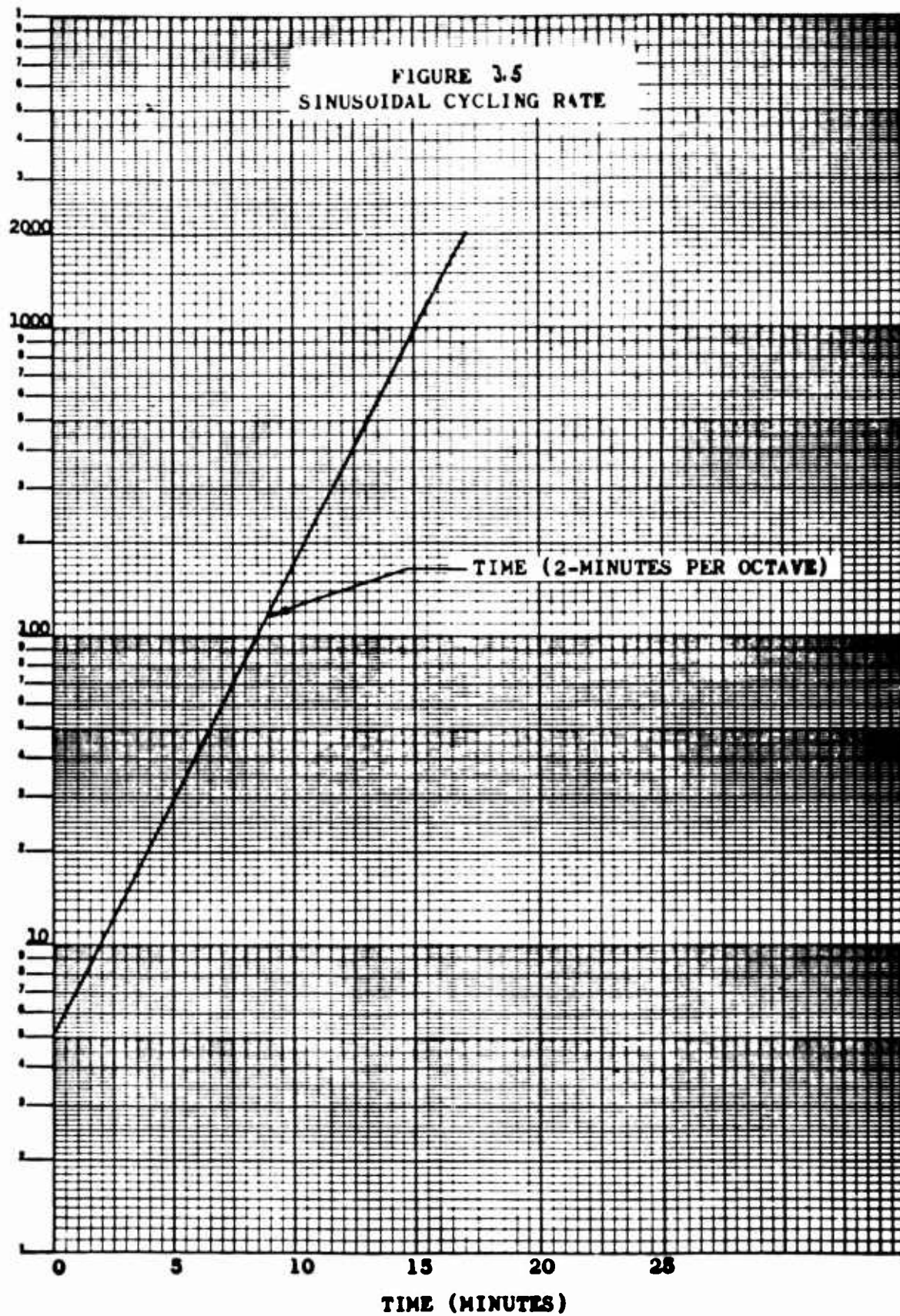
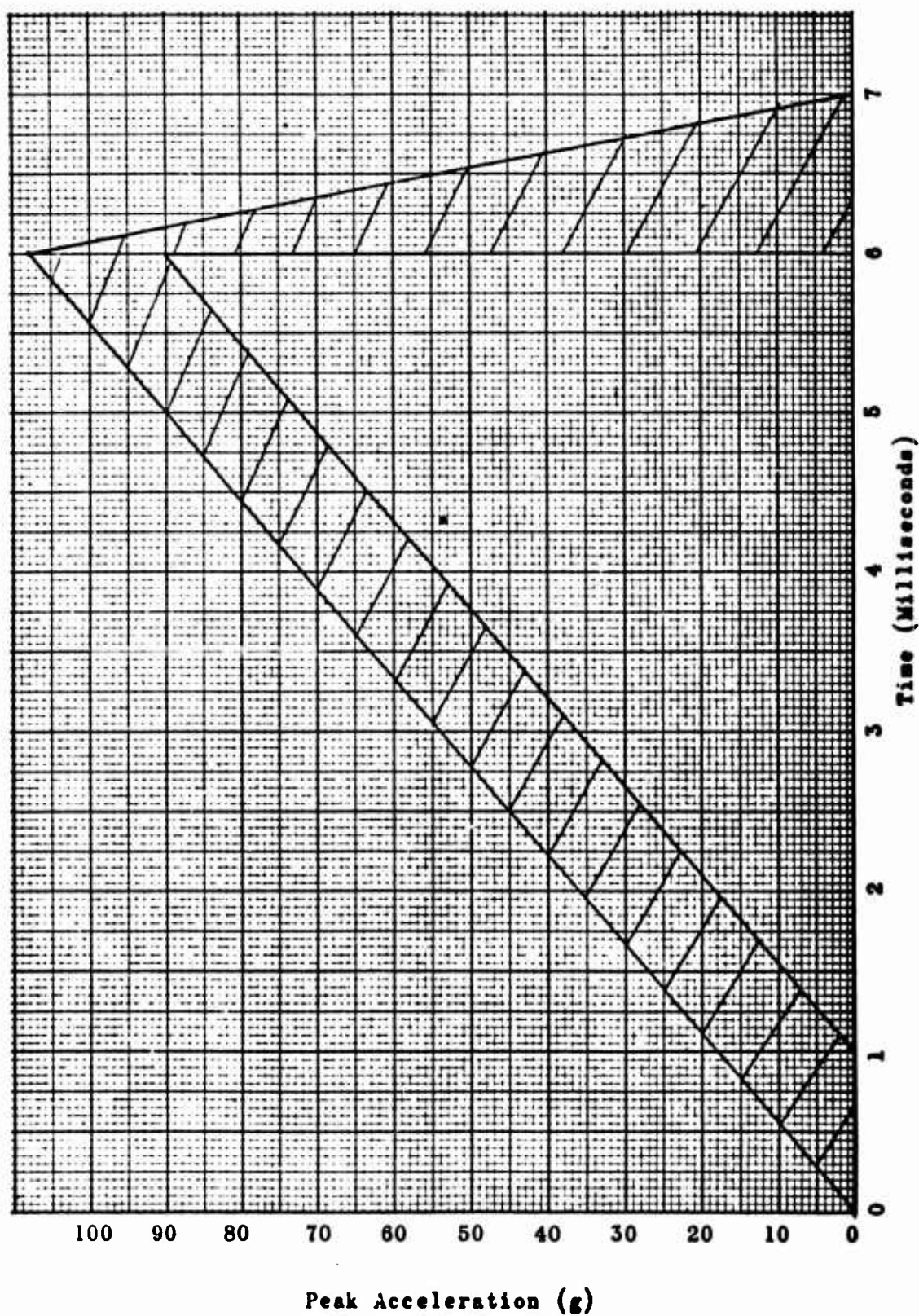


Figure 3.6

Shock Pulse Envelope



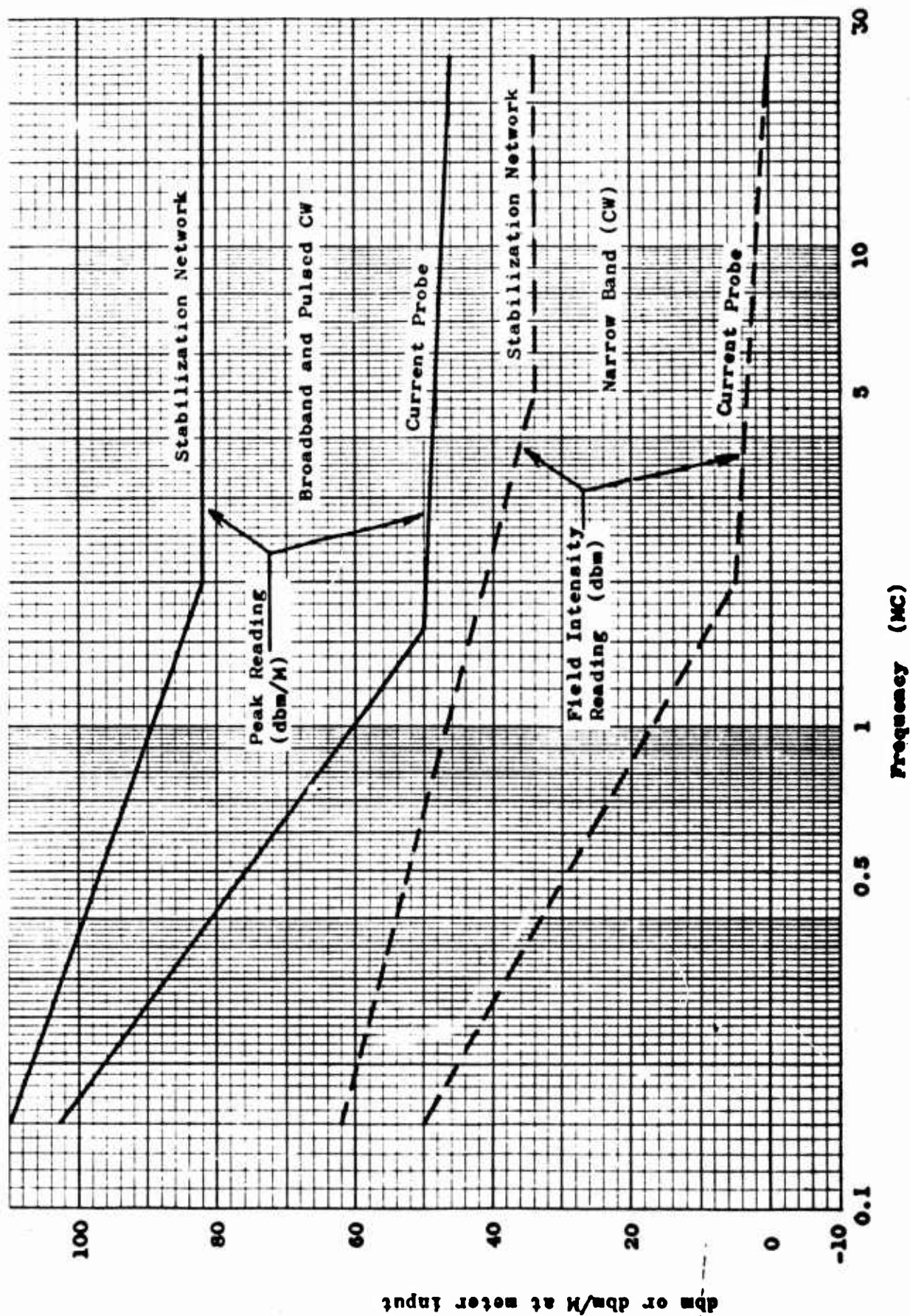


Figure 3.7 Conducted Interference Limits

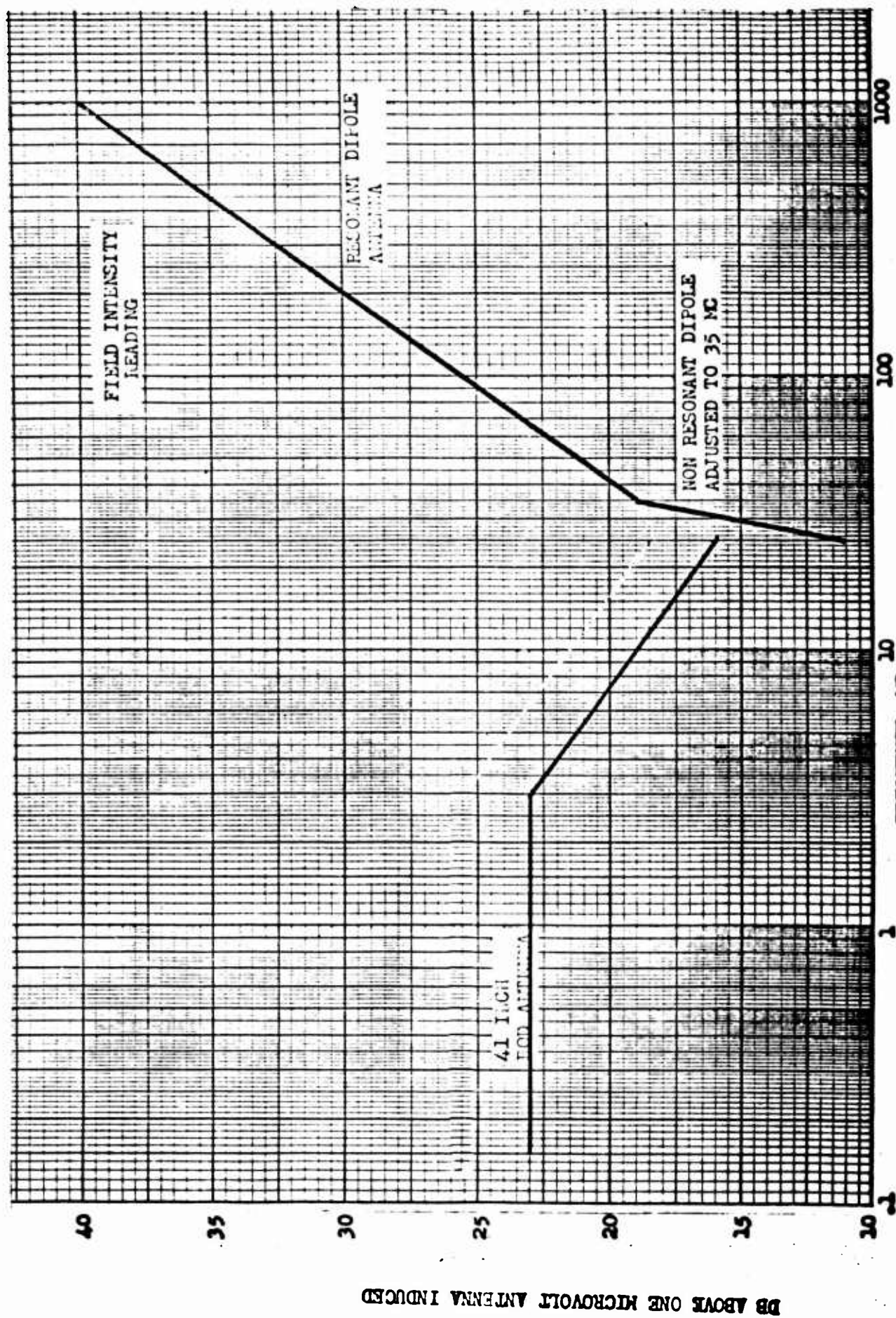


FIGURE 3.8 NARROW BAND (CW) RADIATED INTERFERENCE LIMITS

DB ABOVE ONE MICROVOLT ANTENNA INDUCED

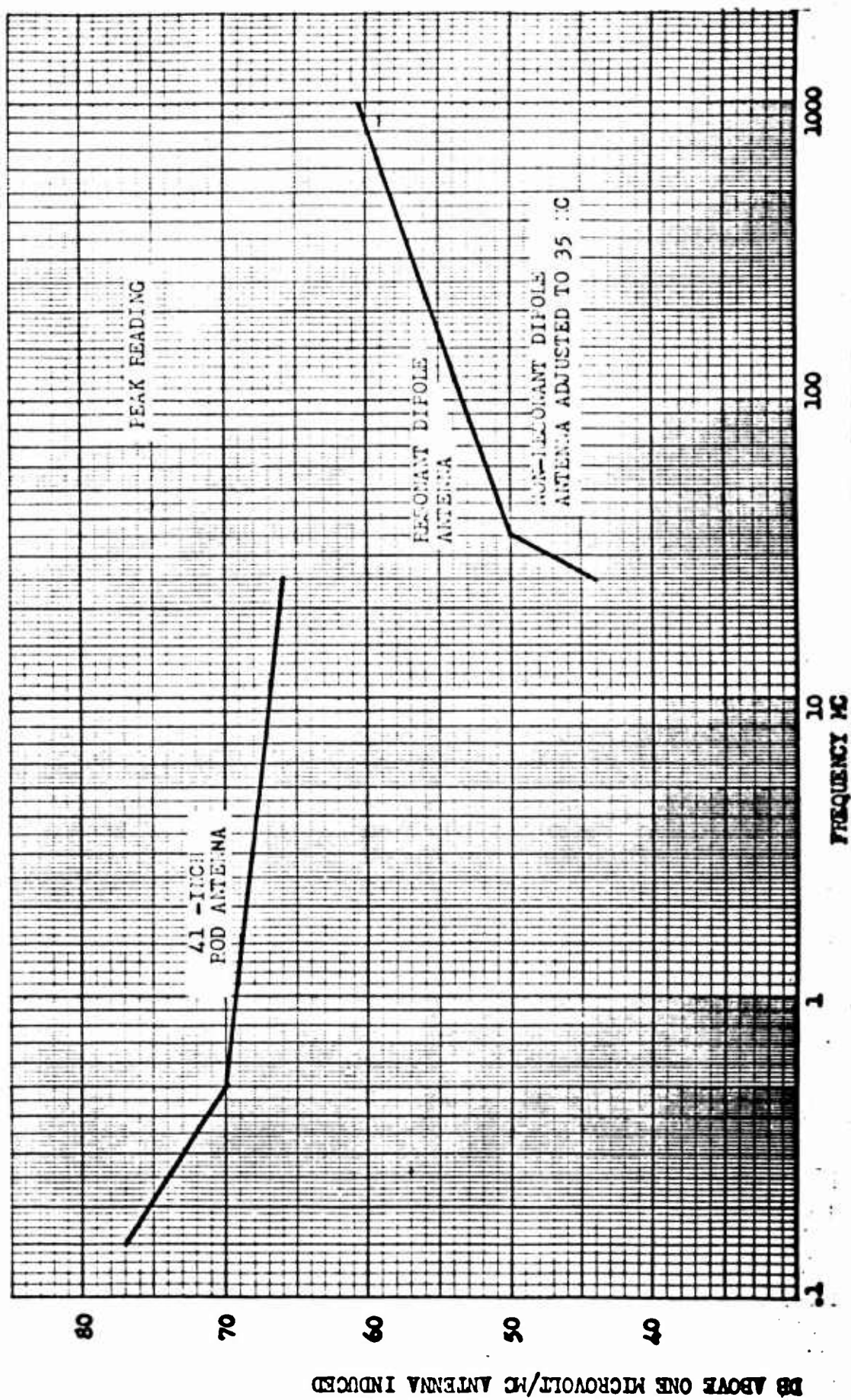


FIGURE 3.7 BROAD BAND AND PULSED CW RADIATED INTERFERENCE LIMITS

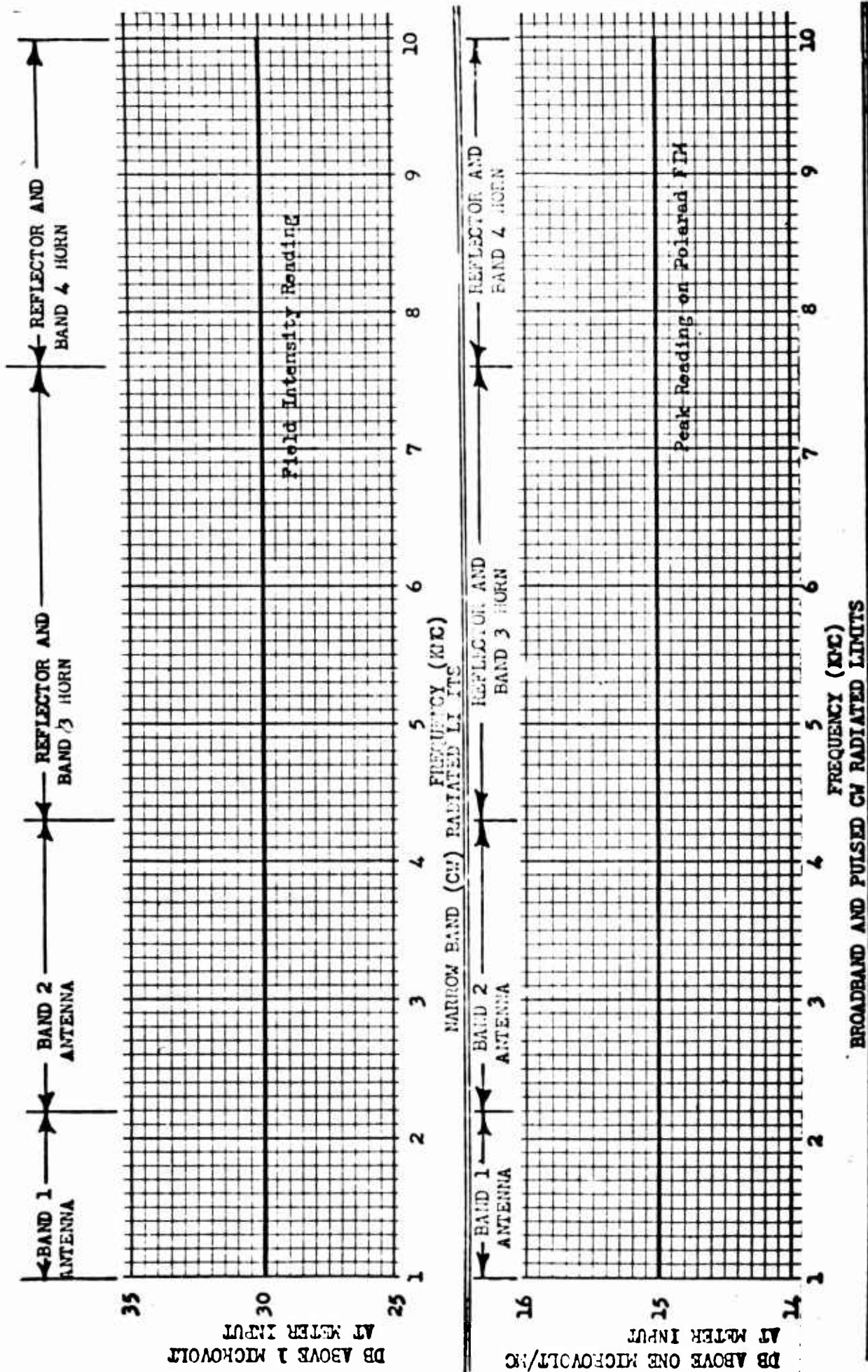
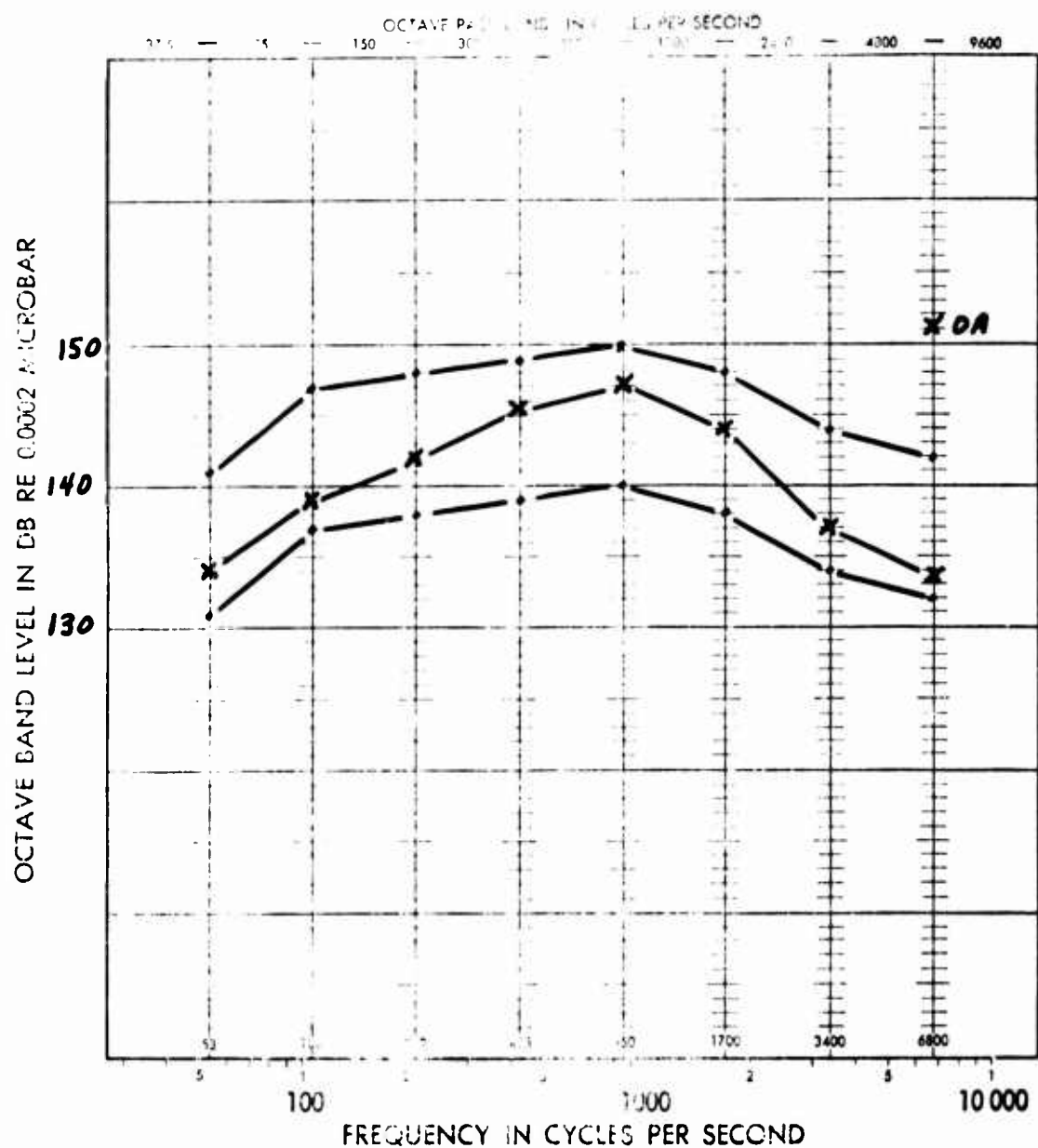


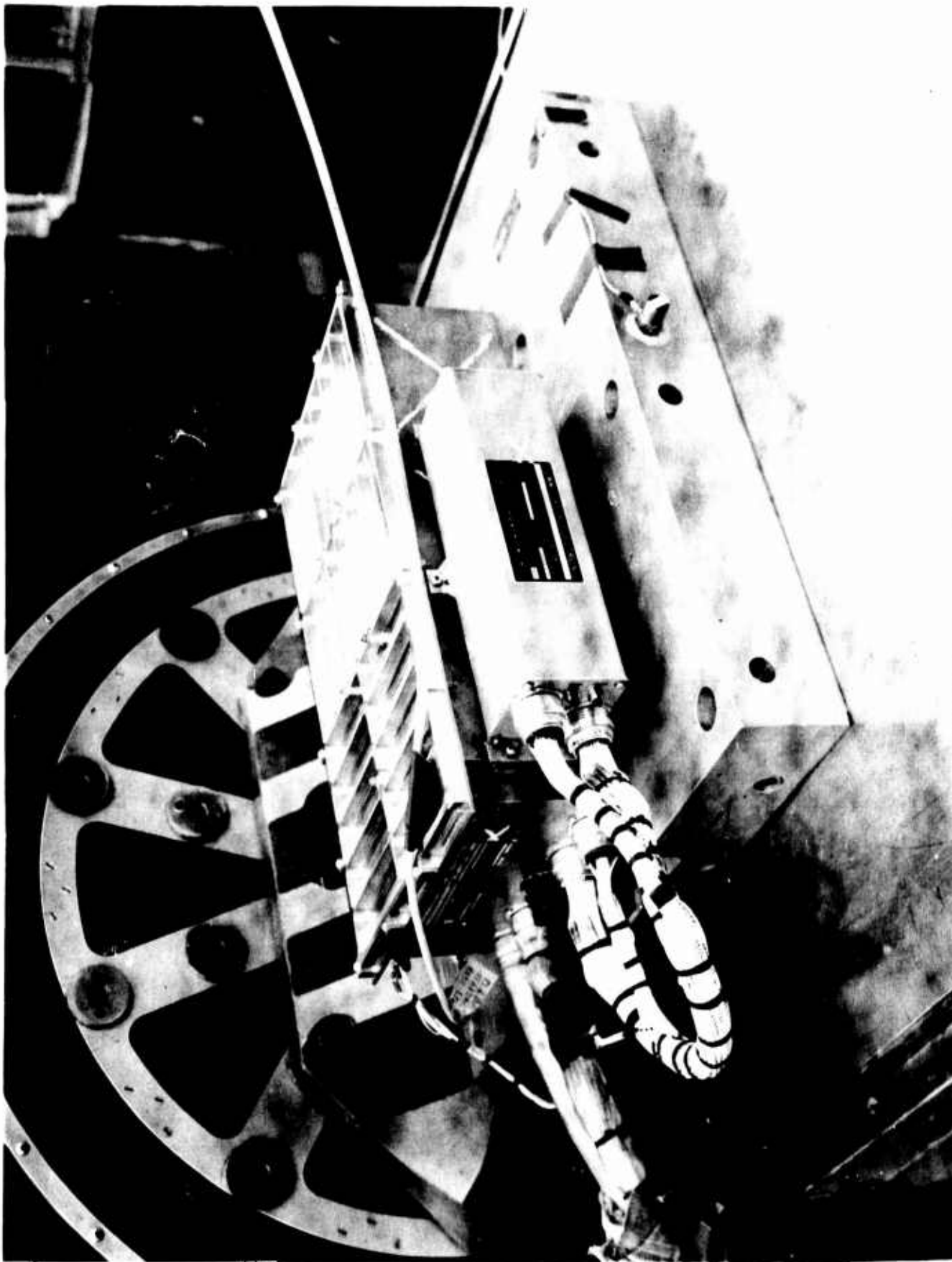
Figure 3.10 Ge Radiated Interference Limits



- . Indicates allowable limits of acoustic input.
 X Indicates actual acoustic levels during test.
 Overall Level is 151 db

**AIRSS TELEPAK
 ACOUSTICAL NOISE TEST**

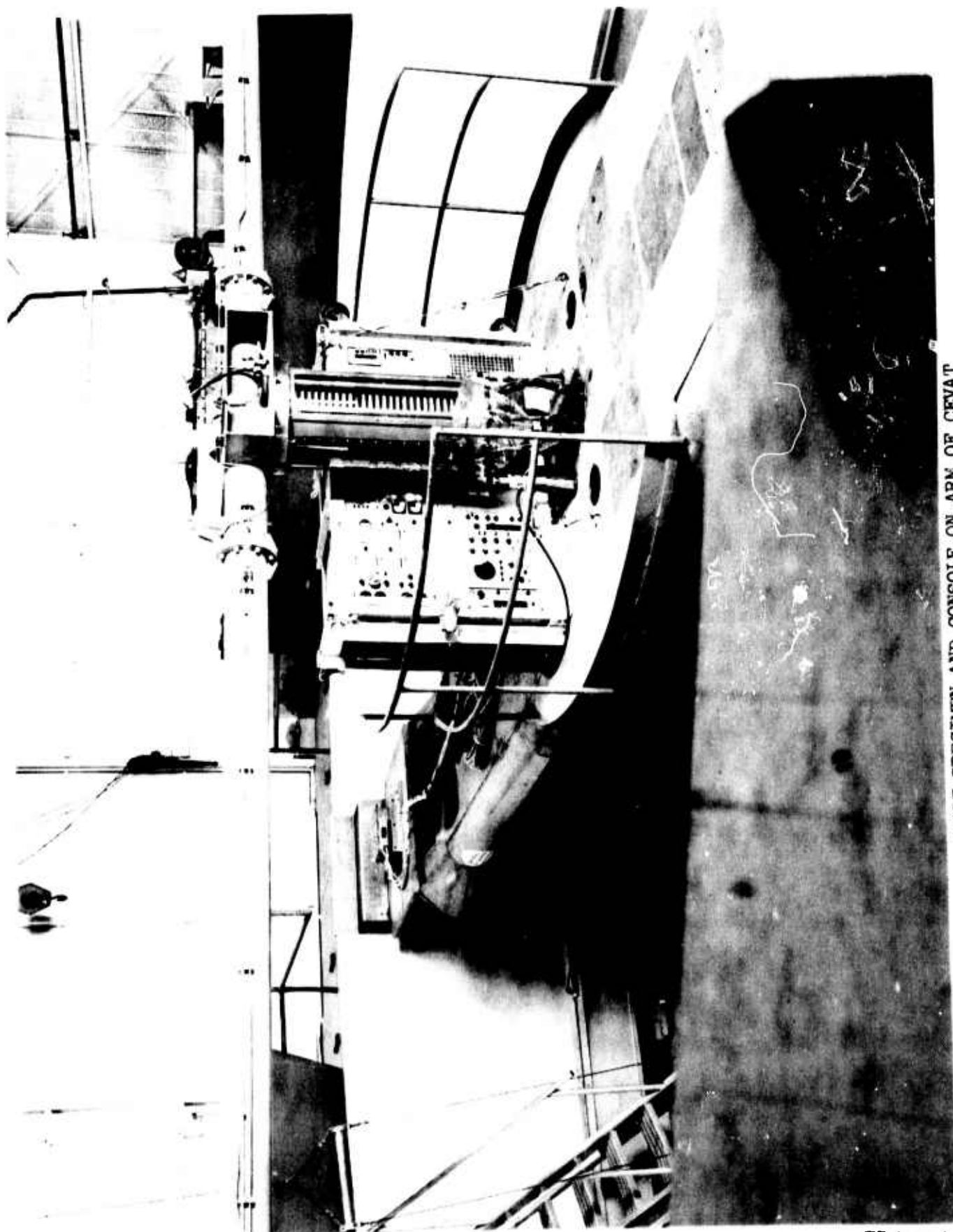
FIGURE 3.11



TEST SPECIMEN MOUNTED FOR "X" AXIS VIBRATION

GD/C Negative No. 75544B

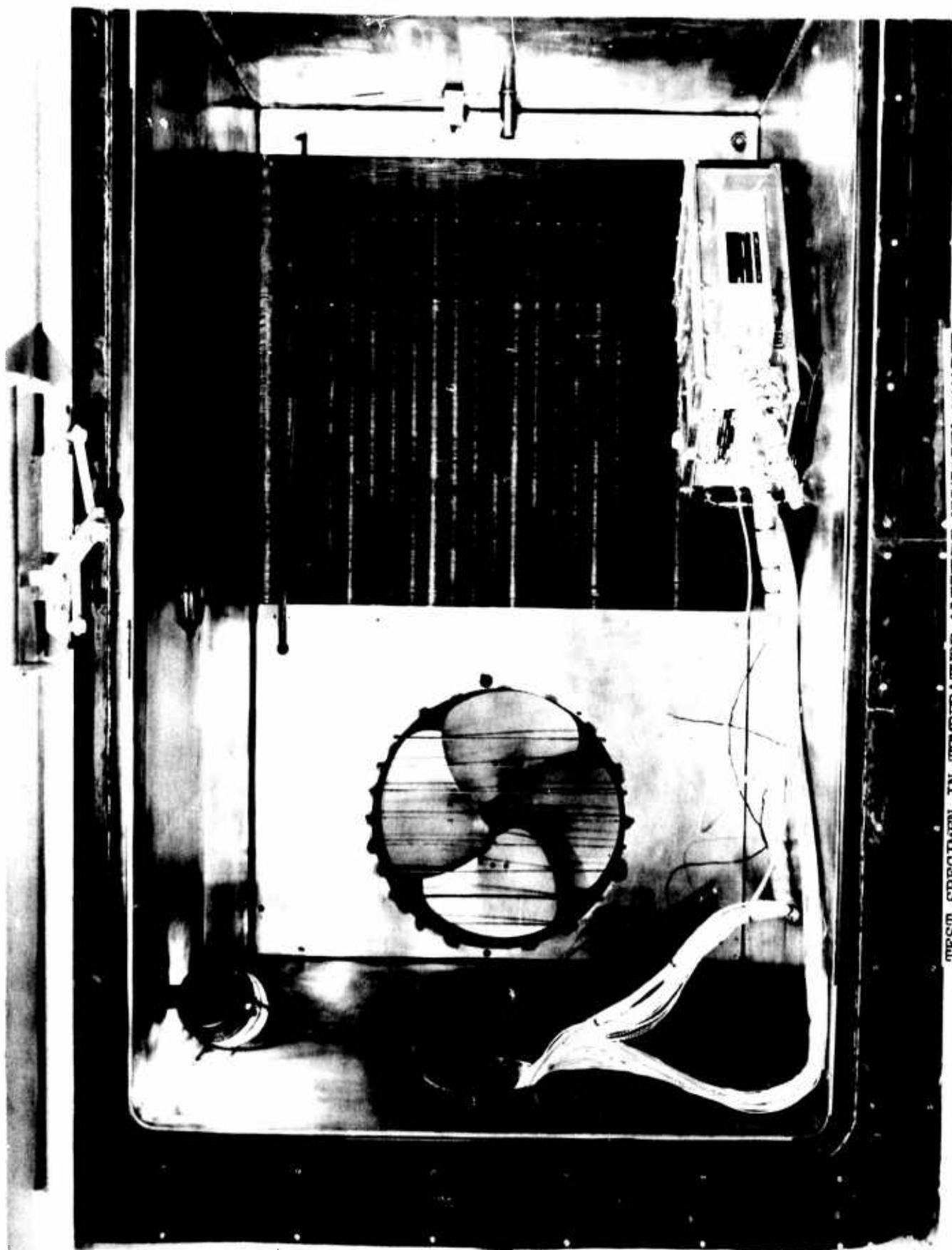
FIGURE 3.2



TEST SPECIMEN AND CONSOLE ON ARM OF CEVAT
FACILITY FOR ACCELERATION TEST.

GD/C Negative No. 75530B

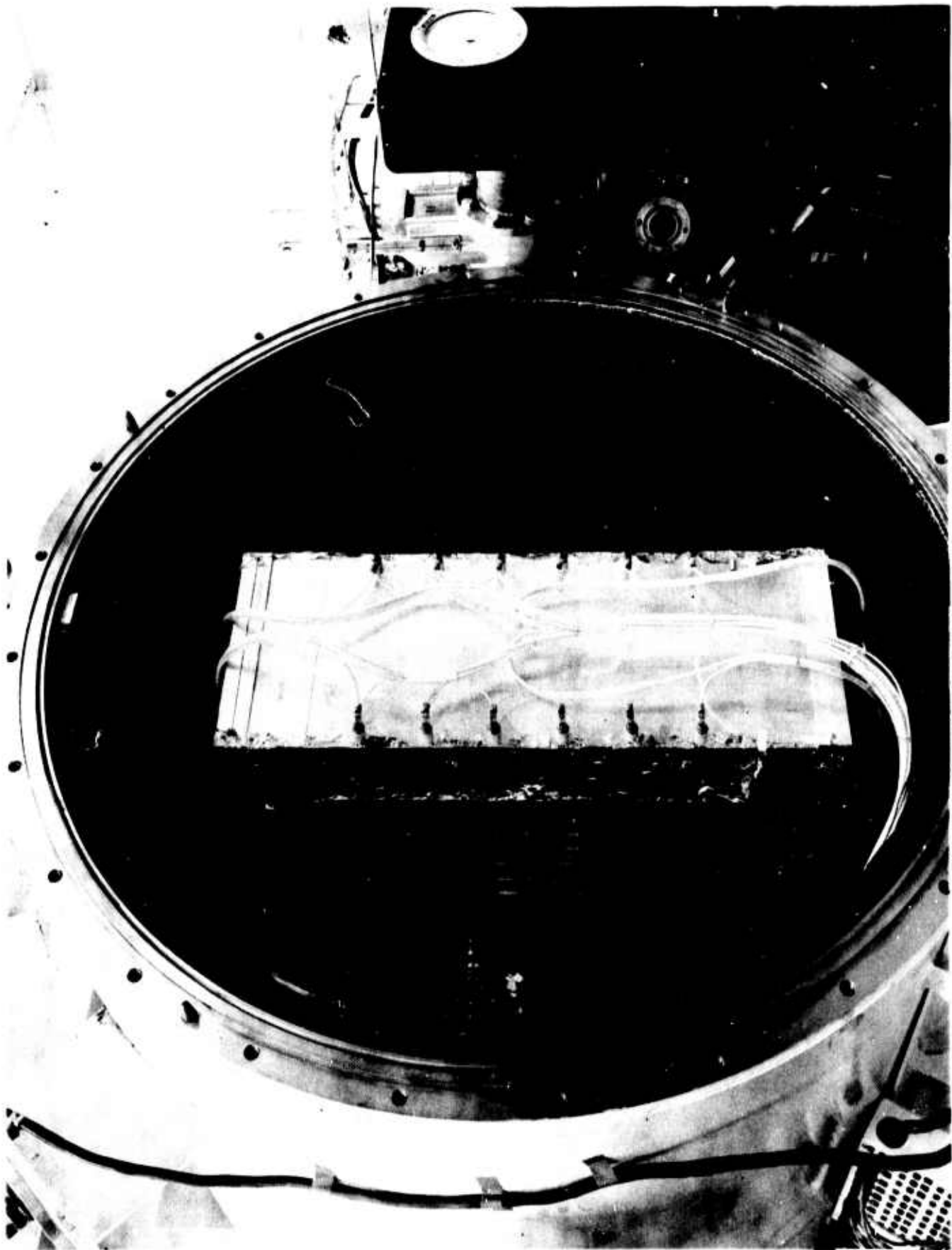
FIGURE 3.13



TEST SPECIMEN IN TEMPERATURE-ALTITUDE-HUMIDITY CHAMBER

GD/C Negative No. 75646B

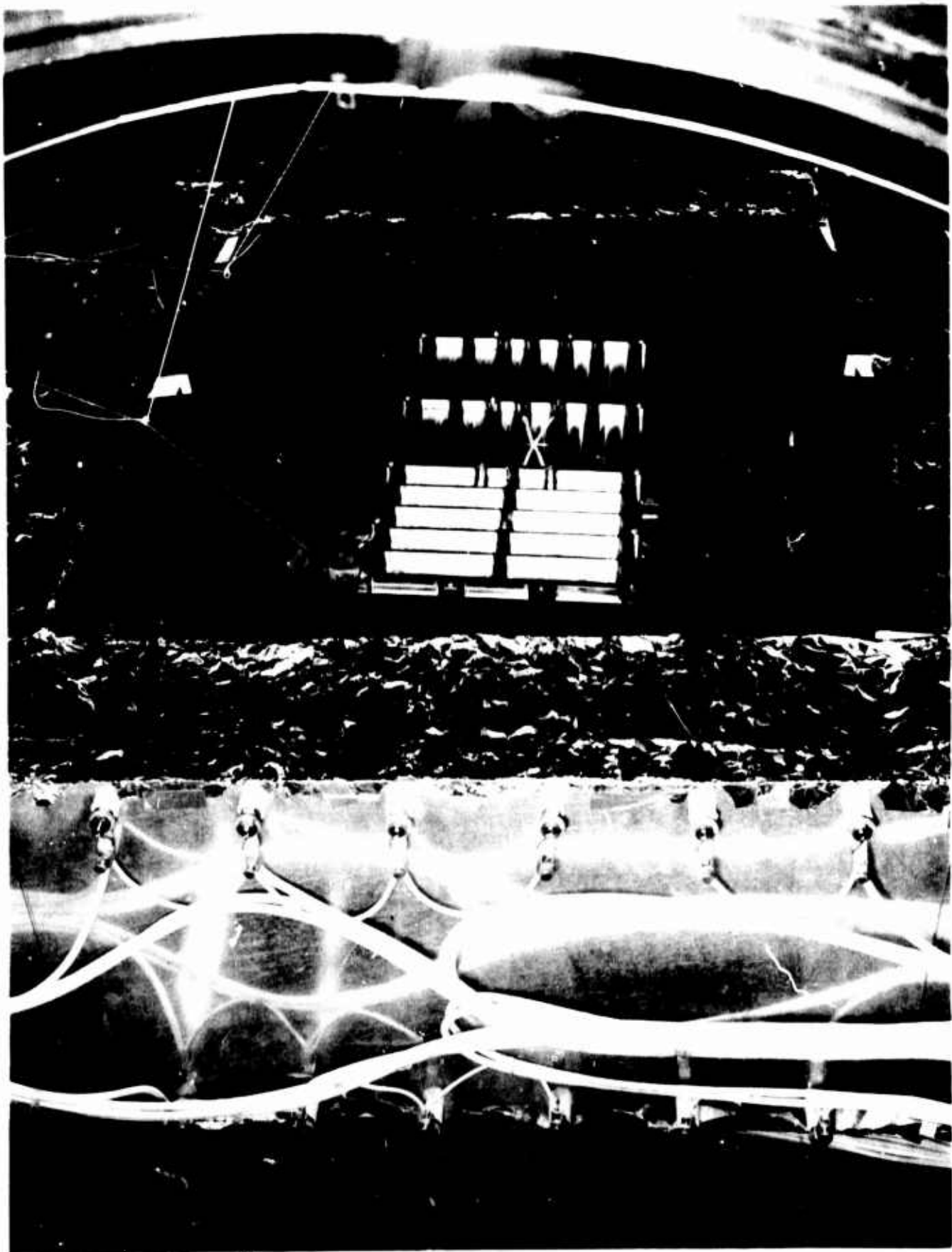
FIGURE 3.14



TEST SPECIMEN MOUNTED FOR ALTITUDE-RADIANT HEAT

GD/C Negative No. 75847B

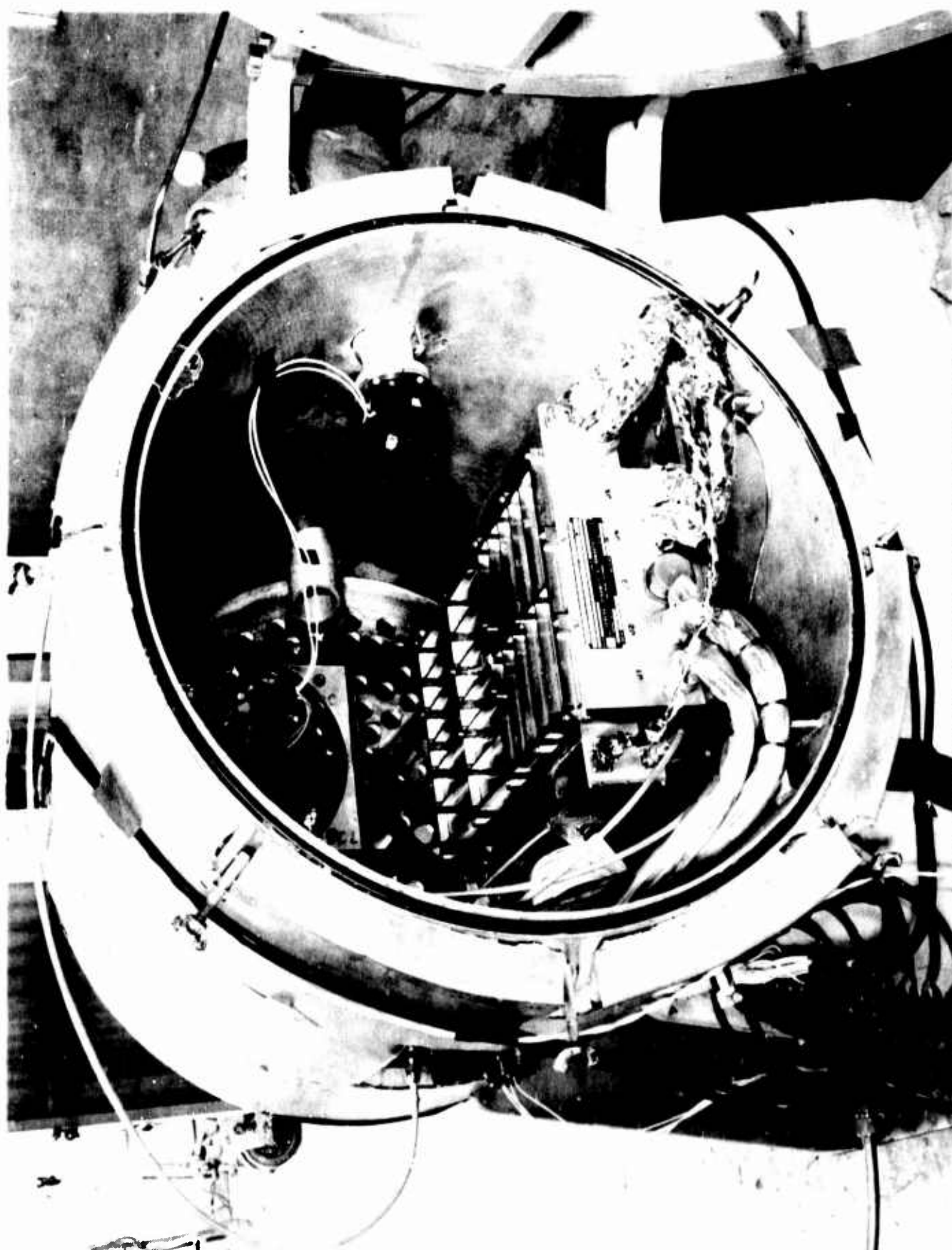
FIGURE 3.15



GD/C Negative No. 75849B

FIGURE 3.16

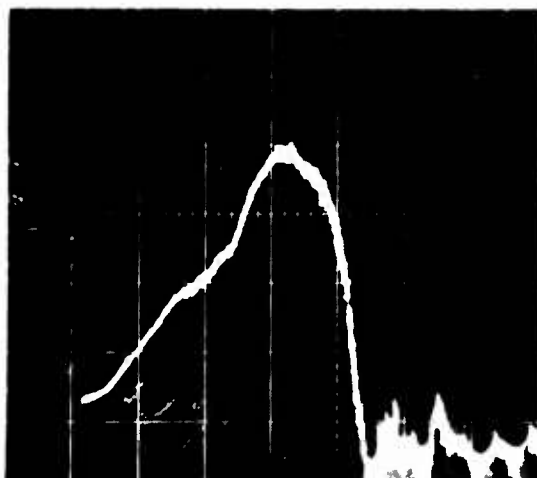
TEST SPECIMEN MOUNTED FOR ALTITUDE-RADIANT HEAT



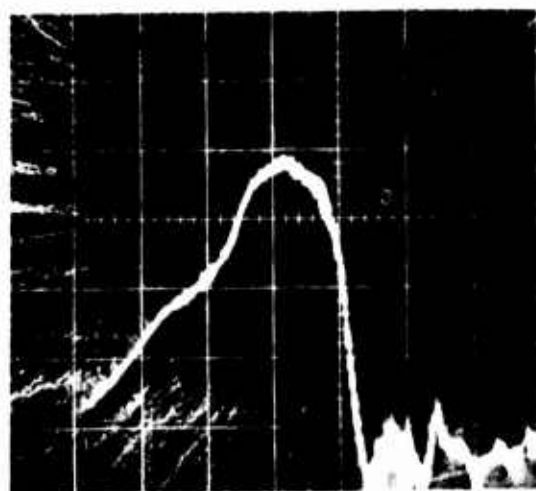
TEST SPECIMEN IN EXPLOSIVE ATMOSPHERE CHAMBERS

GD/C Negative No. 94947B

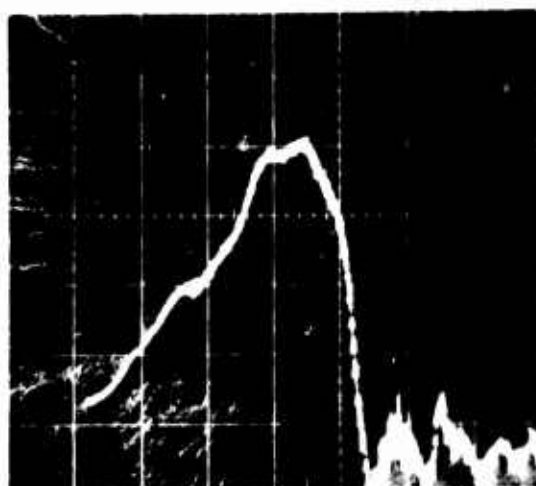
FIGURE 3.17



-Z Axis Shock No. 1
Vertical: 25 g/cm
Horizontal: 2 ms/cm



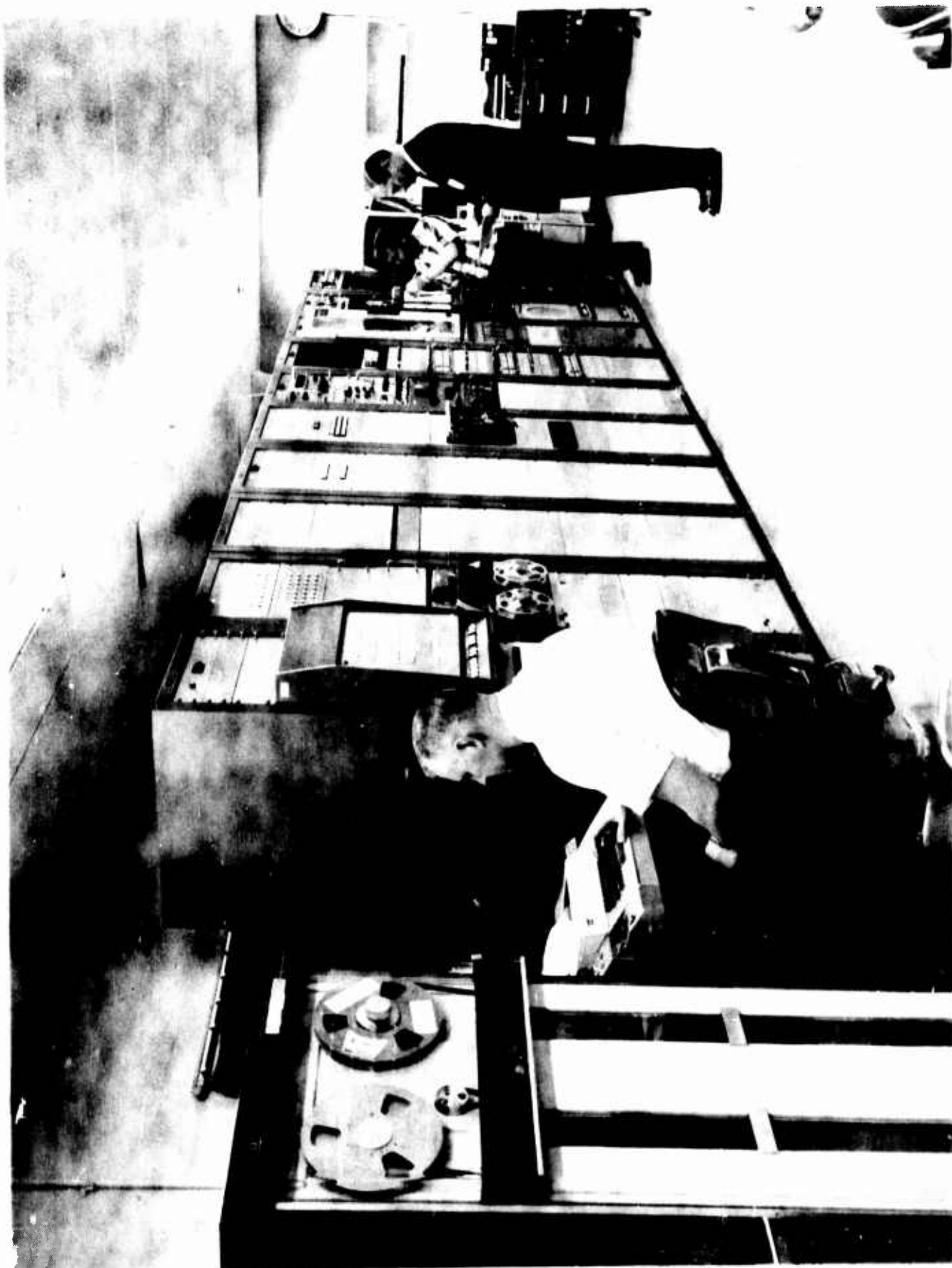
-Z Axis Shock No. 2
Vertical: 25 g/cm
Horizontal: 2 ms/cm



-Z Axis Shock No. 3
Vertical: 25 g/cm
Horizontal: 2 ms/cm

FIGURE 3.18

-Z AXIS SHOCK PHOTOGRAPHS



Data Acquisition Station - DMI 620 Computer and Peripheral Equipment

GD/C Photo No. 83989B

Figure 3.19

Several significant problems were encountered during the above testing. The following is a summary of these problems and their solutions:

Problem: During the 3 axis sine/random vibration environment the transmitter composite output signal became erratic followed immediately by erratic actions in various other signals.

Solution: Investigation determined that all erratic signals were contained in one, small 25 pin connector. Cause was found to be broken or damaged wire connections in the back shell. Additional support was added by potting the wiring in the backshell. This was also accomplished on two other identical connectors in the set.

Problem: During the 3 axis sine/random vibration environment it was noted that several subcarrier oscillator (SCO) frequencies were shifting. In all, six (6) SCOs shifted out of spec.

Solution: Investigation at the vendor's facilities revealed the cause to be damaged solder connections at the base of the Multivibrator module. This module is a "3-D" soldered module consisting of two transistors and seven resistors. On all six failed SCOs, several of the eleven solder connections between this module and the oscillator printed circuits had crystalized under vibration and stress. Quality control actions were initiated to "clench" each lead prior to soldering and support each lead at the base of the module with conformal coating to reduce effects of vibration stresses at the solder connection.

Problem: During the 3-axis sine/random vibration environment channel 12 output became erratic.

Solution: Investigation revealed that the erratic signal was caused by a damaged solder connection on the 64-40137 Limiter Filter Module Board. Damaged connection was one lead from a diode. The diode was not adequately supported allowing component to vibrate excessively during test allowing damage at the connection. Inadequate support was a result of inadequate conformal coating. Only one coat was applied which was not sufficient to "bridge" the components on the board. Quality Control actions were initiated and engineering drawings were revised to call out sufficient "bridging" of all components mounted on printed circuit board modules installed in the signal conditioner unit.

Problem: During the Temperature/Altitude/Humidity test the transmitter failed to operate when turned on while being subjected to a -25°F environment following an 8 hour soak at -45°F.

Solution: Investigation by the vendor revealed the problem was caused by an insufficient bias voltage on the Variable Frequency Oscillator (VFO) stage for the -25°F condition. The circuit was redesigned for higher bias voltage to obtain "hotter" operation at low temperate environment.

Problem: During the Temperature/Altitude/Humidity test, the transmitter frequency was not stable as the temperature was lowered from the upper limit of +160°F. Frequency eventually drifted out of spec. (tolerance is 240.2 mc \pm .005%).

Solution: Investigation revealed the frequency instability was caused by several factors. These were:

1. Inadequate temperature compensation of circuits.
2. Large magnitude of differences in characteristics of like parts.
3. Improper tuning and alignment operation by the vendor.

Additional temperature compensation was designed into the critical circuits sensitive to temperature changes. A parts screening and selection program was initiated on all components for better control over operating characteristics. Vendor technicians were instructed in tuning and alignment procedures.

Problem: During the Radiant Heat/Altitude test the transmitter frequency drifted out of spec (1.5 mc's) when subjected to variations in altitude from sea level to 200,000 feet.

Solution: Investigation at the vendor's facilities revealed that the problem was caused by the RF gasket installed between the unit and its top and bottom covers. The gasket installed was a solid gasket fully covering the total top and bottom areas of the unit. As the altitude increased a vacuum was formed causing the solid gasket to distort into the VFO cavity changing its volume thus creating changes in frequency. Installation of redesigned gaskets with cut-outs corrected the problem.

Problem: Prior to conducting shock tests the telemetry set was turned on and operated at an ambient 60°F temperature. It was noted that the transmitter frequency drifted out of spec after ten minutes of operation.

Solution: Investigation revealed that some components in the mixer and discriminator module of the transmitter were changing characteristics due to inadequate heat transfer during operation. The printed circuit board (fiberglass) was replaced with a metal plate to provide a better heat sink for more efficient heat dissipation.

Problem: During operation following exposure to 95% humidity environment the transmitter frequency was out of spec.

Solution: Investigation revealed that the transmitter housing was not "water tight". The cause was found to be insufficient sealing on the part of the RF gasket between the unit and its top and bottom covers. It was further learned that the gasket material was not waterproof. New gaskets made from a waterproof silver epoxy compound were installed correcting the problem.

Problem: During the course of EMI testing the telemetry set failed in both the power conducted interference and case radiated interference modes.

Solution: Investigation revealed the following:

1. Case radiated interference was attributed to both the transmitter (64-01004) and the commutator (64-01005)
2. Power conducted interference was attributed to both the commutator (64-01005) and the signal conditioner unit (64-40149).

Excessive case radiated interference in the transmitter was found to be caused by RF leakage around both case mounted connectors. The RF shielding gaskets between connector and case were inadequate. This was corrected by the application of a layer of liquid silver epoxy around each connector when mounted in the case. In addition, the top and bottom covers of the transmitter were redesigned to provide an overlapping flange between covers and case to assure increased RF shielding in these areas due to better bonding between covers and cover gaskets.

Excessive case radiated interferences in the commutator was corrected concurrently with the fixes for power conducted interference (see below).

A portion of the power conducted interference was attributed to the signal conditioner unit. There were three (3) basic areas contributing to the problem. These were:

1. Electrical Mount (64-01008) - Excessive RFI was found reduced by the addition of an RF filter in the power line of the -1.25 VDC power supply.
2. Primary Power Supply (64-40135) - Excessive RFI was reduced with additional filtering by means of an added capacitor in the power input circuit of the module.

3. Demodulator (64-40134) - Excessive RFI was reduced by separately grounding each of the 3 demodulators. The "chained" grounding was causing interaction in the demodulator return lines.

Excessive power conducted and case radiated interference was found in the commutator with the major problem centered around power conducted interference. The commutator vendor and Convair conducted analysis of these problem areas and isolated the major causes to the 37 oscillator gate circuits in the unit. These assemblies are used as the commutator switching elements and comprise approximately 50% of the total unit circuitry. The frequency generated within these circuits varied from 15 to 25 megacycles (this is the frequency range where greatest RFI was experienced during EMI testing). It was felt the RFI was being coupled directly from the gate drive lines to the output lines of the commutator. To redesign the 37 circuits was not feasible. Two recommendations were offered by the vendor. These were:

1. Replace the oscillator gate circuits with Field Effect Transistor (FET) circuits.
2. Filter out the RFI on the output lines with the incorporation of line filters in each output line.

Trade-offs were analyzed. It was agreed that incorporation of FET's would solve the problem, however, substantial deviation in critical performance requirements would be required as well as changing the commutator basic operating characteristics.

Overvoltage:	Change from $\pm 35V + 35V$ and $-7V$.
On Resistance:	Change from 100 ohms max. to 500 ohms max.
Output Impedance:	An additional 1000 ohms max. is added to both high and low level channels.

Addition of line filters (LC networks) to each output line was undesirable from the stand point of increased weight and size, however, filtering the RFI rather than replacing gates with FETs, incurred no changes in operating characteristics.

Filtration by use of line filters was adopted and implemented. The qual test unit was reworked and modified. Further EMI testing indicated power conducted interference was within the acceptable limits of MIL-1-26600 with the exception of interference from 15.4 to 17.0 megacycles (5db above allowable). This area was corrected by the addition of two RF filters in the 28V power line within the signal conditioner unit.

The filtration by line filters required the insertion of 141 filters into the unit which in turn required a new larger case design for additional space. The new case is silver plated for the purpose of correcting the case radiated interference problem attributed to the case design.

The qualification testing was successfully completed with resolutions to the above problems and implementation of described corrections. It should be noted that the AIRSS telemetry set is fully qualified in accordance with the technical requirements of the contract with no deviations.

3.4 ACCEPTANCE TESTING

Acceptance testing of each individual telemetry set was performed to assure each unit is the equal of that which successfully passed the qualification tests. This assurance was demonstrated by performing an acceptance test under environmental conditions approximating those used during qual testing, namely vibration and temperature.

Vibration: While in an operative condition, each telemetry set was subjected to a random vibration test of 7.6 g (rms) for 2 minutes along each of the three orthogonal axes. The shape of the random vibration spectrum approached that of the flight environment of the Atlas E/F missile. Performance parameters were continually monitored during the test by performing a proof cycle of all operational outputs while operating to simulated inputs. Proof cycles were performed each eleven (11) seconds. Due to the large volume of data to be monitored all outputs were continually fed into the DMI 620 computer system for comparison with established standards. A go - no go posture is thus established by means of an on-line computer analysis.

Temperature: While in the operative condition the telemetry set was subjected to 120°F for a period of 2 hours. The temperature was then raised to 150°F and allowed to stabilize. When the unit had stabilized at 150°F the temperature was then lowered to 20°F then allowed to stabilize. When stabilized the temperature was lowered to -25°F and stabilized for one hour. Temperature was then returned to ambient. Performance was monitored throughout the test period again by means of an on-line computer hook-up to the DMI 620 computer system.

3.5 FLIGHT TESTING

A flight test demonstration of performance was required by the contract. This was to be accomplished by flying an AIRSS telemetry set 'piggy-back' on two Atlas missile flights. Assignment to missiles was the responsibility of the Air Force.

The AIRSS telemetry set and special harnessing was to be installed in such a manner as to parallel approximately twenty (20) prime instrumentation measurements through the AIRSS unit for monitoring AIRSS performance by comparison of data with prime system data. Selection of measurements was to be made so as to be made so as to exercise the major portions of the AIRSS unit.

During the course of the AIRSS production contract, the Air Force was unable to acquire assignments of either "piggy-back" unit for an Atlas missile because of extenuating circumstances. This requirement is presently being deleted as a contract requirement. It should be noted that as of the publication date of this document, five (5) operational AIRSS systems have flown down-range on Atlas E/F missiles with no known performance problems.

SECTION 4

RELIABILITY

Built-in reliability is a very real feature of the AIRSS telemetry set resulting from a vigorous reliability analysis program conducted as a requirement of the contract. The basic reliability requirement in the design and development of the AIRSS End Item is, design and fabricate a telemetry set with a probability of mission success within its life time of .995 for an operational period of 20 minutes in the immediate period prior to launch in the ground environment and an operational period of 500 seconds in the immediate post-launch period under the predicted airborne operating environment.

To accomplish this analysis an "AIRSS Reliability Model" was established. Specific tasks were performed and controls used to insure implementation of the reliability requirements which produced the necessary inputs for the model. These are:

- Reliability Prediction and Apportionment
- Component and Systems Specification Review
- Detailed Reliability Analysis
- Component, Subsystem and System Testing
- Failure Reporting

Ground rules and assumptions used in the analysis were applied uniformly to subcontractor equipment as well as equipment manufactured by Convair. These ground rules and assumptions are:

1. All failure rate data are taken from MIL-HDBK-217, "Reliability Stress and Failure Rate Data for Electronic Equipment" and the "Failure Rate Data Handbook" (FARADA), published by the Bureau of Naval Weapons.
2. When a part was derated to the point that its failure rate did not appear on the failure rate graph, the lowest failure rate value on the graph was accepted as the part failure rate. This resulted in a conservative estimate of the failure rates for these parts.
3. The equipment operating time during countdown and flight was considered to be 20 minutes and 500 seconds respectively.
4. Failure rates were increased by a factor of 80 during the time the equipment is in a flight environment. (This "K" factor is recommended in MIL-STD-756A. "Reliability Prediction Procedures").
5. The predicted reliability represents the inherent or "built-in" reliability of the equipment and excludes consideration of failure resulting from human error.

The reliability analyses for the AIRSS telemetry set is the result of a closely coordinated effort between the design and reliability engineering functions. During the early formulation of system specification requirements, the AIRSS reliability goal was apportioned among the major AIRSS components. The apportioned goals were then included in the specifications as an integral part of the equipment design requirements. Suppliers of major AIRSS subcontracted components were further required to submit a reliability analysis that support attainment of the reliability goals contained in the specifications. In order to insure consistency in the analyses the ground rules, including the failure rate data sources to be used, were also made a part of each specification.

Additionally, a derating policy was established for Convair produced equipment requiring that a part's operating stress should not be greater than 50% of the part's rated capacity.

Design review was conducted on a continuing basis. Recommendations for design changes that would tend to improve system reliability were made while the design was in its early stages. Design changes were thus incorporated and the final drawings were approved by reliability engineering with minimal delay to the program.

RELIABILITY SUMMARY

Component	Apportioned Reliability Goals	Predicted Reliability	Losses Per 1000 Flights
R ₁ Commutator	.998740	.998704	1.30
R ₂ Transmitter	.998060	.999864	0.14
R ₃ SCO Mounts (2)	.999910	.999811	0.19
R ₄ Subcarrier Oscillators (10)	.999315	.999217	0.78
R ₅ Mixer Amplifier	.999610	.999950	0.05
R ₆ Signal Conditioner	.999335	.999131	0.87
System Reliability	.9950	.9967	3.2

APPENDIX I

"PROGRAM CHRONOLOGICAL MILESTONES"

1-3-66	Award of Contract
1-21-66	Preliminary Design Review Accomplished
1-24-66	Procurement of Long Lead Material Initiated
2-18-66	Began initial fabrication of production details
2-21-66	Development testing initiated
2-25-66	Completed award of contracts to long lead procurement vendors
3-11-66	Initiated receiving inspection tasks on fifteen (15) IRSS End Item Kits (27-0803), GFP furnished
3-31-66	Critical Design Review of "Hybrid" AIRSS configuration accomplished
4-20-66	Received first production transmitter, mixer amplifier, subcarrier Oscillator and mounts from Dorsett Electronics.
5-12-66	Received first production commutator from Stellametrics
5-20-66	"Design Freeze" of "Hybrid" AIRSS configuration established.
5-25-66	Completed fabrication of Factory Support Test Equipment
6-10-66	Mockup of "Hybrid" AIRSS configuration on Missile 119F completed
6-14-66	Completed receiving inspection tasks on fifteen (15) IRSS Kits
6-15-66	Completed fabrication and assembly of "first" article telemetry set.
6-16-66	FACI - Phase I was initiated
6-16-66	Qualification Testing of "first" article telemetry set initiated.
7-18-66	FACI - Phase I completed
8-5-66	Preliminary Design Review for "Piggy-back" Flight Test configuration accomplished.
8-22-66	GDC directed to submit proposal to supply shortages to GFP furnished IRSS Kits.

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8-25-66	Design for "Piggy-back" installation on Missile 148F completed.
9-16-66	Stellarmetrics Commutator failed Electronic Magnetic Interference (EMI) requirements during Qualification Testing.
9-17-66	Qualification Testing suspended until resolution of EMI problem.
9-21-66	GDC and Stellarmetrics met first time to discuss redesign of commutator to correct EMI problem.
9-29-66	GDC and Stellarmetrics met second time and agreed on nature of redesign to commutator to correct EMI problem.
9-30-66	Stellarmetrics initiated redesign effort on commutator.
9-30-66	Design of "Full" AIRSS configuration completed.
11-8-66	Critical Design Review of "Full" AIRSS accomplished.
11-12-66	Prototype of modified Stellarmetrics Commutator received for evaluation tests.
11-18-66	Mockup of "Full" AIRSS configuration on Missile 75F completed.
12-16-66	First modified production Stellarmetrics commutator received and qualification testing resumed.
1-15-67	Qualification testing of AIRSS telemetry set completed.
1-24-67	GDC directed to submit ECP to modify AIRSS Baseline (ECP 5452)
1-26-67	Qualification test data approved.
2-8-67	FACI - Phase II completed.
2-15-67	Supplement Agreement No. 10 to contract deleted on "piggy-back" Flight Test requirement.
2-28-67	GDC recovered to the contract delivery and incentive schedule with delivery of article 64-1004-19.
3-6-67	ECP 5452 for AIRSS Baseline Modification submitted.
3-31-67	Articles 64-1004-20 and -21 delivered during March.
4-30-67	Articles 64-1004-22, -23 and -24 delivered during April.
5-15-67	ECP 5452 approved and "go-ahead" authorized under the AF04(694)-788 contract.

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5-31-67 Article 64-1004-25 delivered during May.

6-30-67 Articles 64-1004-26 and -27 delivered during June.

7-31-67 Articles 64-1004-28, 29, 30 and 31 delivered during July.

8-31-67 Article 64-1004-32 delivered during August.

9-30-67 Articles 64-1004-33, 34, and 35 delivered during September
all hardware deliveries completed.